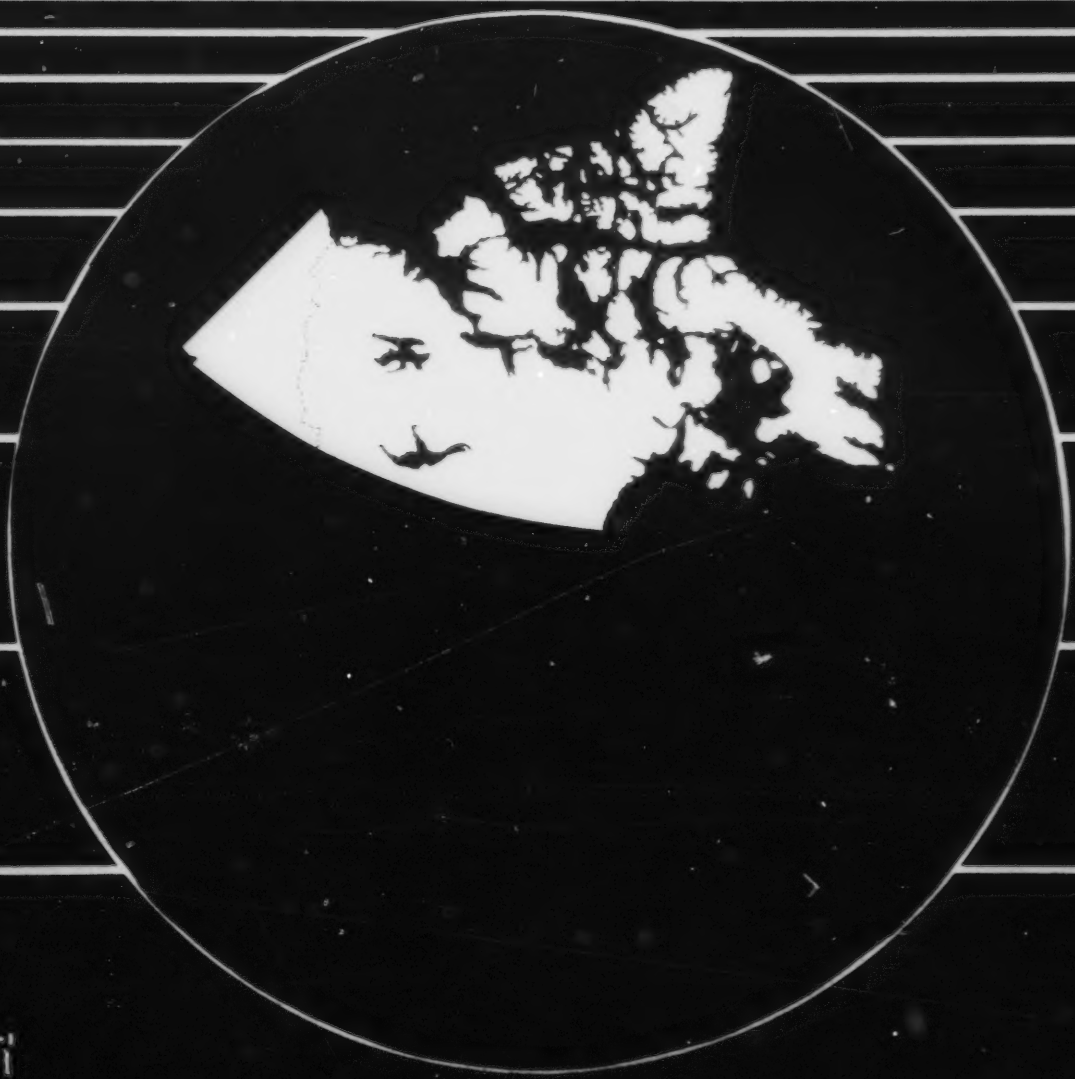
Environmental Studies No. 68

Synopsis of Research Conducted Under the 1991/92 Northern Contaminants Program



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Synopsis of Research Conducted Under the 1991/92 Northern Contaminants Program

From a Workshop in Support of the Technical and Science Managers Committees on Northern Ecosystems and Native Diets, Ottawa, Ontario. March 24-25, 1992.

Northern Affairs Program

Editors: J.L. Murray
R.G. Shearer

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The views, conclusions and recommendations expressed herein are those of the authors and not necessarily those of the Department.

Foreword

This report provides a summary of the results of research and monitoring studies undertaken in 1991/92 concerning contaminants in northern Canada, under the auspices of the Green Plan's Arctic Environmental Strategy. This knowledge base was the subject of a scientific evaluation workshop held in Ottawa, Ontario, March 24-25, 1992.

Approximately 40 scientists, representing a broad spectrum of interests, attended the meeting. Formal presentations were made that dealt with all aspects of the northern contaminants issue, including sources and transport; contamination of freshwater, terrestrial and marine systems; human exposure through diet; and finally, implications to human health.

These results were evaluated to ensure that they supported the overall program objectives. The results were also used to set and re-align program priorities for 1992/93.

A participants list for the meeting is found in Appendix I.

Préface

Ce rapport stipule le résumé des résultats de recherches et études surveillés entreprises sous les auspices de la Stratégie pour l'Environnement Arctique du Plan Vert du Canada en 1991/92 concernant les contaminants dans le nord Canadien. Ces connaissances de bases font l'objet d'un atelier d'évaluations scientifique qui a en lieu à Ottawa, Ontario, le 24-25 mars, 1992.

Environ 40 scientifiques, représentant divers intérêt ont participés à cette réunion. Des présentations formelles concernants toutes les aspects de problèmes des contaminants, incluant les sources et le transport; contamination d'eau douce, terrestre et marine; contamination humaine par la diète; et enfin, l'implication sur la santée humaine.

Ces résultats ont été évalués, pour assurer qu'ils supportent les objectifs global du programme. Les résultats ont aussi été utilisés pour ré-alignés lea prioritées du programme pour 1992/93.

La liste des participants à la réunion est retrouvé dans l'appendice I.

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Introduction

The 1991/92 fiscal year was the first year that the research, monitoring and evaluation of northern contaminants was conducted under the auspices of the Green Plan's Arctic Environmental Strategy (AES). This ongoing research program, initiated in 1985 in response to concerns related to the presence of persistent organic, metal and radionuclide contaminants in the north, aims to identify the sources and pathways by which these pollutants are entering the Arctic and to provide a scientific basis for the assessment of their effects on the northern environment, its wildlife, and its people. Particular emphasis is placed on determining the health risks to northern aboriginal populations as a result of their reliance on traditional food sources - fish, seal, whale, polar bear and caribou - in which toxic chemicals may concentrate.

Over the year, a number of federal and territorial government departments and universities participated in approximately 35 separately-funded studies totalling $3.5 million of the program's $35 million, six-year budget. Research proposals are evaluated, and funding is awarded based on their scientific merit in relation to clearly defined program priorities as well as their anticipated or demonstrated contribution to the objectives set out in the Program's Five-Year Research Plan. Many are cooperative, interrelated projects whereby researchers representing a broad range of highly specialized fields of expertise share results and advice. The program's multidisciplinary, integrated approach and the degree to which results are communicated are vital to its achieving progress towards its goal - to understand and ultimately reduce or, where possible, eliminate contaminants from the arctic environment.

The focus of Canadian action has largely been on organochlorines and their effects on the ecosystem and human health. This will likely remain the priority over the short term. However, the effects of other contaminants such as metals (e.g. mercury and cadmium) and radionuclides will continue to be studied.

Significant progress was also achieved in 1991/92 with respect to Canada's participation in international initiatives. With the knowledge that distant sources, via air and water currents, are the major contributors of pollutants to the Canadian Arctic, Canada maintains an active role in a number of international task forces, studies, and conventions designed to measure and control the release of persistent contaminants. Examples of these activities include the Declaration on the Protection of the Arctic Environment which was signed by all eight arctic nations in Rovaniemi, Finland in June 1991, and the United Nations Economic Commission for Europe Task Force on Persistent Organic Pollutants which Canada co-chairs with Sweden to develop a protocol for international control of these substances. In addition, Canada and Russia (formerly the Soviet Union) are currently carrying out joint studies on arctic

contaminants under a bilateral agreement on Cooperation in the Arctic and the North.

Approximately 40 scientists representing a broad spectrum of interests attended the scientific evaluation workshop in Ottawa, Ontario, March 24-25, 1992. The workshop was divided into three sessions which dealt with sources, sinks and pathways of northern contaminants, ecosystem contaminant uptake and health effects, and human health. A similar workshop was conducted last year in Burlington, Ontario, April 3-4, 1991. Further workshops to evaluate results and progress of research and monitoring studies will be conducted annually to ensure that the results support the overall program objectives and to set and re-align program priorities.

This report provides a summary of the results of research and monitoring studies undertaken in 1991/92 concerning contaminants in northern Canada as discussed at the Ottawa workshop.

SOURCES, SINKS AND PATHWAYS OF NORTHERN CONTAMINANTS

SOURCES, SINKS AND PATHWAYS
OVERVIEW

Recent Findings

1) Shelf sediments in the Arctic Ocean contained higher organochlorine concentrations than deep basin sediments. Shelves, which have greater sedimentation rates, may provide an important sink for organochlorines.

2) Monitoring of organochlorines (OCs) in air, snow, ice, seawater and crustaceans at the Canadian Ice Island has shown that PCBs, toxaphene, HCB, isomers of HCH, DDT and chlordane are present in all environmental samples.

3) A large number of organochlorine compounds have been found in sediments of northern lakes. Recent results suggest that the amount of DDT in surface sediments declines with an increase in latitude, whereas PCB concentrations remain the same.

Polycyclic aromatic hydrocarbons (PAHs) decreased with depth in sediments of lakes measured between 50 and 75° N, suggesting an increase in deposition of these compounds compared to historical background levels. However, there was a subsurface maximum of PAHs in lakes located at 50 and 64° N, implying that present inputs are lower than those of the recent past. The finding that this pattern was more pronounced in lakes at 50° N suggests that these lakes are closer to the source of PAHs.

Mercury concentrations in lake sediments declined with an increase in latitude and an increase in depth.

Knowledge Gaps

1) Information on global use patterns, emissions and sources of the persistent organic contaminants of concern is lacking for most regions, especially for the former Eastern bloc countries.

2) Currently, the level of understanding of atmospheric transport mechanisms and atmospheric transformation processes of trace organics is inadequate.

3) Information on temporal and spatial variability of contaminant deposition to land is sparse.

4) Physical/chemical properties of trace organics at zero and sub-zero temperatures need to be quantified.

5) Revolatilization of contaminants needs to be quantified and the processes controlling these losses need to be characterized.

6) Overall, basic information is still required to quantify inputs, trajectories and how contaminants cycle once in the Canadian north.

7) There is a need to ensure integration of subject areas (e.g. air, water, snow sampling and analyses) in selected regions and to determine if these regions are representative of the Arctic.

Future Work

1) Contaminant emissions on at least a hemispheric scale will be estimated for input to models which are being adapted to study the movement of atmospheric contaminants on an hemispheric scale and their exchange between the atmosphere and the earth's surface.

2) Air samples will be collected weekly at Alert on northern Ellesmere Island and at Tagish in southern Yukon for analyses of 18 PAHs and 90 organochlorines.

3) A 12-month over-wintering study will be conducted at Resolute Bay for seasonal sampling of biota to document changes in organochlorines and lipid levels of lower marine food web systems. Mass balance calculations will be carried out to determine the relative importance of atmospheric vs. oceanic organochlorine input to lower trophic levels of the marine food web.

4) Water and sediment will be sampled in Liverpool Bay and the Husky Lakes in the Beaufort Sea region to determine the importance of shallow, shelf areas for scavenging organochlorines to sediments.

5) The total contaminant load delivered by major river systems to the arctic marine environment will be characterized and estimated. Studies will be carried out to determine the sources of contaminants to these rivers.

6) Large volume water and snow samples were collected at lakes, rivers and a pond in the Yukon River Basin and will be analyzed for organochlorine pesticides, PCBs, PAHs and trace metals in order to investigate contaminant sources within this system.

7) The Amituk Lake Basin on Cornwallis Island will be studied in detail to characterize how contaminants deposited in the Arctic move through the aquatic system and accumulate in the ecosystem.

8) Annual deposition and historical residue trends of trace organic contaminants in arctic glaciers will be measured. The major processes controlling the fate of these contaminants will be studied.

9) Appropriate methods to quantify trends of contaminant deposition in peat bogs will be identified.

ORGANOCHLORINES AND POLYCYCLIC AROMATIC HYDROCARBONS IN THE ARCTIC ATMOSPHERE

PROGRAM LEADER: L.A. Barrie, Atmospheric Environment Service, Environment Canada

PROJECT TEAM: L. Barrie, T. Bidleman, K. Brice, J. Kovalick, D. Muir, D. Toom, P. Fellin (contractor)

OBJECTIVES:

To measure the occurrence of selected organochlorines and polycyclic aromatic hydrocarbon compounds in the arctic atmosphere for a period of two years thereby providing insight into environmental transport, removal, transformation and surface exchange processes as well as data for the development of realistic environmental pathways models.

DESCRIPTION:

Introduction

As a result of a comprehensive review of the sources, occurrence and pathways of northern contaminants (Barrie *et al.*, 1992), it is apparent that little information is available on the occurrence in the atmosphere of these potentially toxic substances. Such information is necessary if an understanding of their sources, pathways and impacts on the arctic environment is to be achieved.

There exists only a few observations of the atmospheric abundance of these compounds attained through short term (6-8 weeks) intensive field studies scattered over a few years and locations.

Activities in 1991/92

Upon receipt of funds in August 1991, a contract was let to Concorde Scientific in Toronto to build on their research supported by the Atmospheric Environment Service in FY 90/91 that produced an optimal instrumental package for sampling in the Arctic on a routine basis. A high volume sampling system had been developed that had a 10 μm diameter particle cutoff, the capability of dividing the compounds of interest sampled at 1 cubic meter per minute into particulate and gaseous fractions and depositing them on pre-cleaned filters that can subsequently be chemically analyzed in a central laboratory. What remained to be done was the preparation of such a system for the Arctic, the development of sample handling and collection procedures, analytical testing of the sample preparation procedure and preparation of a suitable field measurements facility and protocol. By early 1992, everything was prepared for the initiation of a sample test program. A laboratory facility at Alert on northern Ellesmere

Island was prepared for the installation of the sampler on 20 January 1992. Since that time, weekly samples have been taken and shipped to Concorde Scientific in Toronto where they have been extracted into hexane solvent. The extracts have been analyzed for at least 18 PAHs and 90 organochlorines by D. Muir's Department of Fisheries and Oceans laboratory at the Freshwater Institute in Winnipeg. K. Brice of the Atmospheric Environment Service will provide an independent check on the analysis through exchange of split extracts.

As of 31 March 1992, analyses were nearing completion so no results are available for FY 91/92.

CONCLUSIONS AND FUTURE DIRECTIONS:

A robust arctic air sampler for organochlorines and polyaromatic hydrocarbons has been developed and demonstrated to function under Arctic conditions. The first routine measurements in the High Arctic at Alert, begun in January 1992, will be followed in September 1992 by a second set of observations at a southern arctic location. These stations will be operated for a period of two years until September 1994. They will be co-located with measurements of these compounds in snow made by D. Gregor of Inland Waters Directorate of the Department of Environment.

In addition to routine observations, special studies will be conducted with two samplers at Alert to characterize the precision and representativeness of the routine samplers.

REFERENCE:

Barrie, L.A., D. Gregor, B. Hargrave, R. Lake, D. Muir, R. Shearer, B. Tracey and T. Bidleman. 1992. Arctic contaminants: sources, occurrence and pathways. In: The Science of the Total Environment 122 (1/2): 1-74, E.I. Hamilton and J.O. Nriagu (eds.).

VERIFICATION OF CONTAMINANT SOURCE DATA

PROGRAM LEADER: E.C. Voldner, Atmospheric Environment Service

PROJECT TEAM: T. Bidleman, D. Gregor and A. Li

OBJECTIVE:

On a global scale, determine sources and atmospheric emission of acidifying and toxic pollutants, such as SO_x, NO_x, volatile organic compounds (VOC), metals and pesticides.

RATIONALE:

Estimation of contaminant source data (emissions) on a global scale is required for input to models (ref. to project: Northern Hemispheric Chemical Transport Model) for the determination of source regions that may have a significant impact on sensitive areas such as the Arctic and the Great Lakes regions. Establishment of source/receptor relationships and relative contributions of sources in other countries to receptors in Canada will allow assessment of control strategy scenarios and hence aid Canada in the development of international control policies. Evaluation of historical and future trends in emissions are important for understanding and predicting response time of various components of the ecosystem to changes in the atmospheric load.

DESCRIPTION:

Acidifying Species and Metals

The initial effort will focus on SO_x, NO_x, VOC and lead. Information on anthropogenic emissions will be sought from organizations or programs throughout the world or estimated through surrogate methods such as emission factors and statistical information on fuel use, production capacity, population, etc. A computerized data base will be created and emissions will be gridded for input to models. The emission inventories will be updated as the information base improves.

Pesticides

Phase I involves the compilation of information and the creation of a computerized data base of historical, present and predicted global usage or sales of persistent pesticides such as Aldrin, Dieldrin, Chlordane, DDT, Endosulfan, Endrin, HCH, Lindane, Heptachlor and Toxaphene. The information sought includes amount of use/emission; region of use/emission; mode and time of application; and physical and chemical properties of the active

ingredient as well as of the technical mixture. The information will be obtained through literature surveys and contact with international agencies.

Phase II consists of the determination of time-dependent, spatially gridded emission inventories of the specified compounds for input to the hemispherical/global model. Based on the information obtained in Phase I, regionally representative crop and soil data, as well as climatological hourly meteorological data, a time-dependent numerical model will be executed to quantify the emissions. The latter model was developed by the Atmospheric Environment Service for predicting the volatilization of pesticides and other toxic materials from vegetated soils. Emission estimates will be compared with limited measurements.

Phase III will involve, if warranted, an expansion to the Northern Hemisphere of a North American study on emissions of current use pesticides, being conducted under the Great Lakes Water Quality Program.

ACTIVITIES AND FUTURE DIRECTIONS:

The past year has essentially been devoted to the search for and retrieval of basic information as well as further development of the air/soil exchange model. Figure 1 provides an example of emissions of chlordane after initial incorporation into the soil. The progress has been slower than expected due to difficulties in obtaining information, deficiencies in information obtained, delay in funding and subsequent placement of contracts.

Data for SO_x, NO_x, VOC, and Pb for various regions have been compiled and are being quality controlled. First estimates of annual emission inventories of SO_x and NO_x are available as shown in Figure 2. First estimates of annual inventories of lead and VOCs and improved estimates for SO_x and NO_x are expected to be completed during FY 1992/93.

Battelle Research Centre in Geneva, Switzerland and the International Registry for Potentially Toxic Chemicals (IRPTC) of the United Nations have been contracted to provide information on worldwide organochlorine usage. Figure 3 shows countries surveyed for 1987. A literature search has been performed and other organizations contacted for additional information. Data is being analyzed. It is expected that a first cut inventory of HCH will be available in FY 1992/93, while other inventories will be available in FY 1993/94.

Clients/Partners: Arctic Environmental Strategy, Great Lakes Water Quality Program, UN ECE Task Forces on Persistent Organic Pollutants and Heavy Metals, International Joint Commission, and Global Emissions Inventory Activities under the International

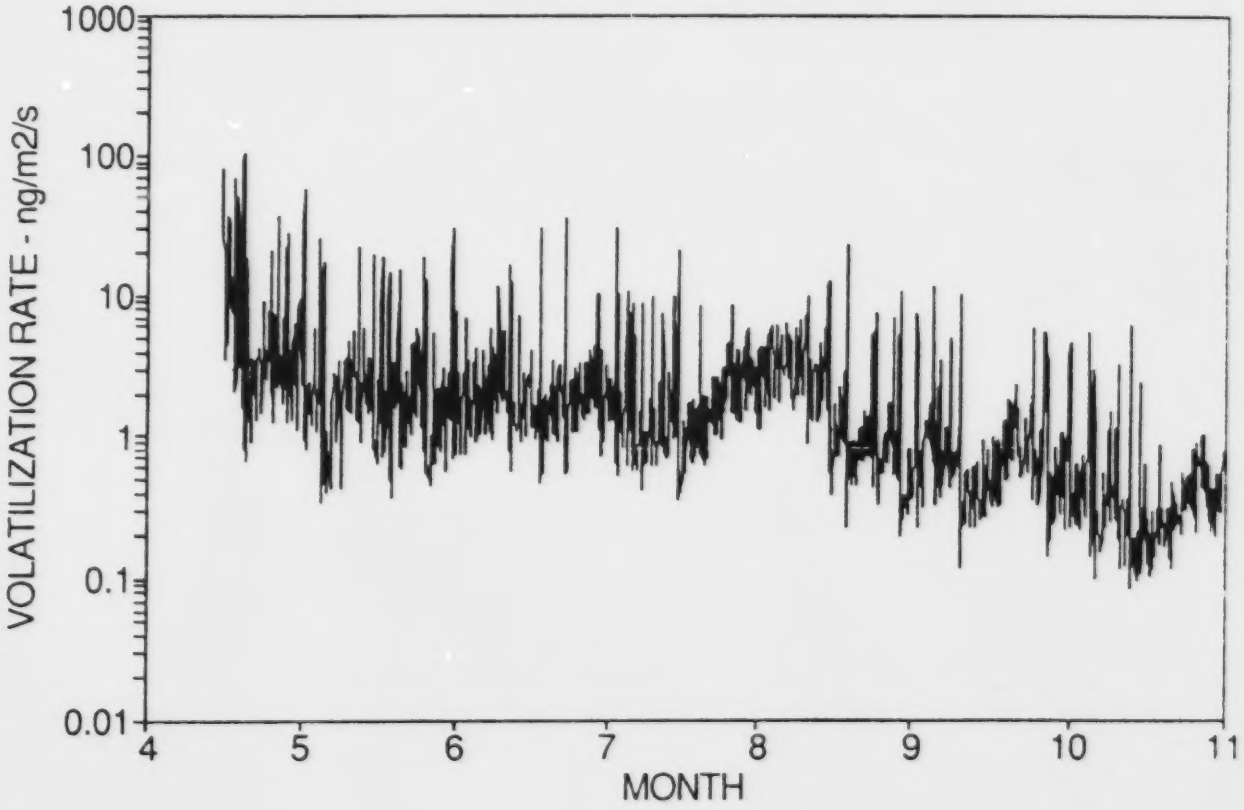
Biosphere Program. Contractors: Ortech International, Mississauga, Canada; Biosphere Program, Geneva, Switzerland; and UN IRPTC, Geneva, Switzerland.

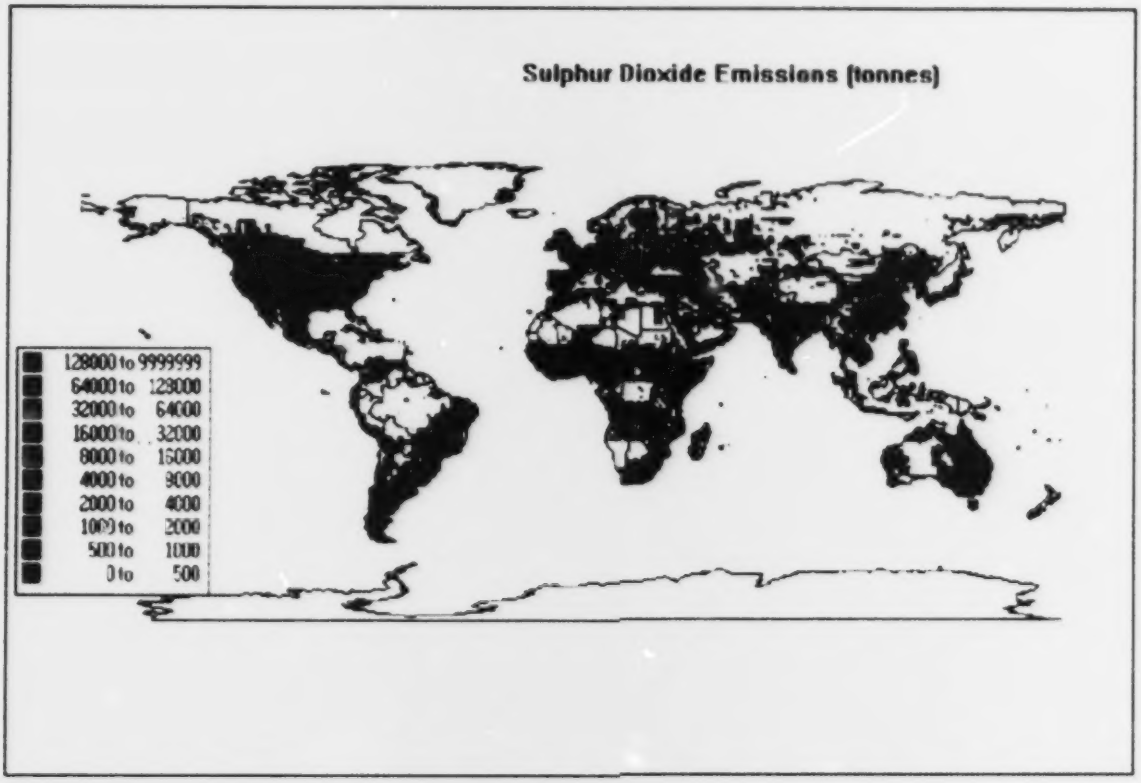
RESOURCES:

	1991/92	1992/93
Green Plan AES ($K)	200	50

FIGURE 1:

CHLORDANE VOLATILIZATION- MARCH-OCTOBER
Incorporated to 10 cm. SANDY-LOAM




Sulphur Dioxide Emissions (tonnes)
128000 to 9999999
64000 to 128000
32000 to 64000
16000 to 32000
8000 to 16000
4000 to 8000
2000 to 4000
1000 to 2000
500 to 1000
0 to 500

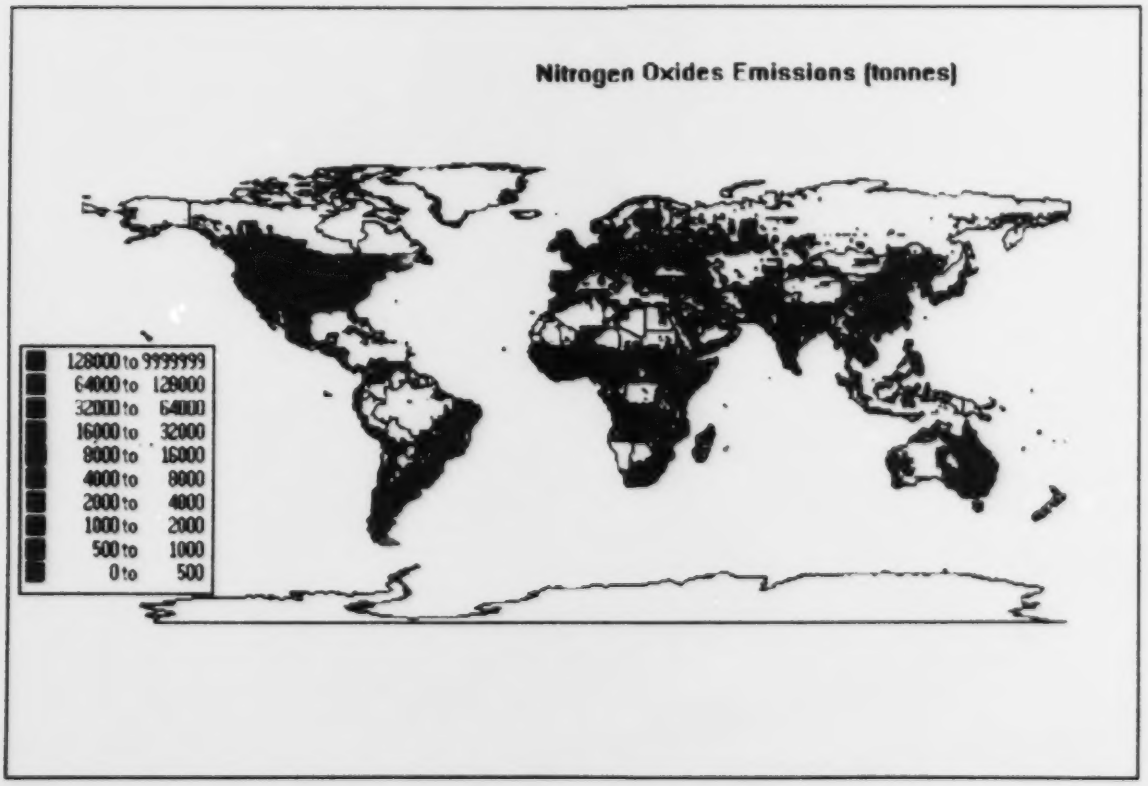
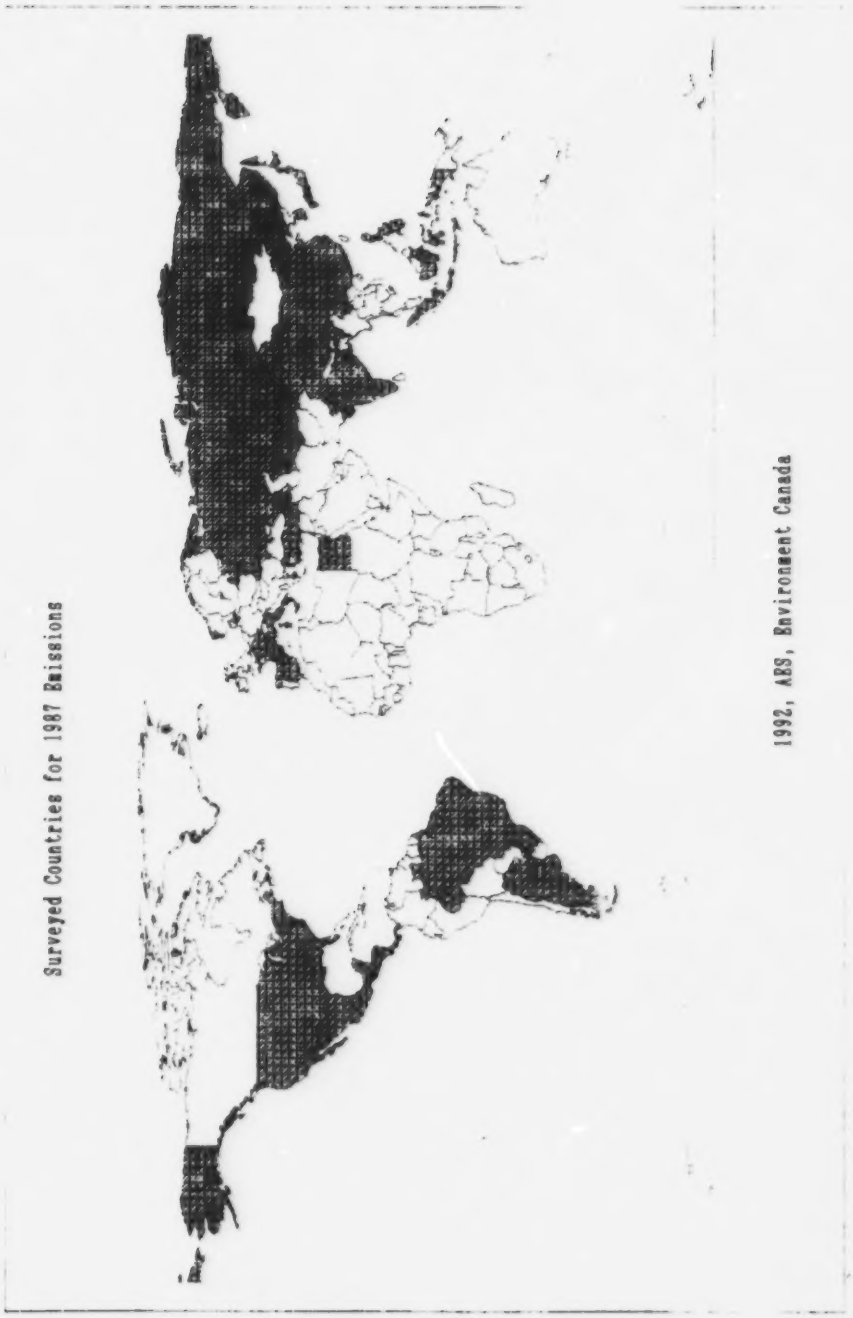

Nitrogen Oxides Emissions (tonnes)
128000 to 9999999
64000 to 128000
32000 to 64000
16000 to 32000
8000 to 16000
4000 to 8000
2000 to 4000
1000 to 2000
500 to 1000
0 to 500

Figure 3


Surveyed Countries for 1987 Emissions
1992, ABS, Environment Canada

NORTHERN HEMISPHERIC CHEMICAL TRANSPORT MODEL

PROGRAM LEADERS: J. Pudykiewicz and A. McMillan, Atmospheric Environment Service

PROJECT TEAM: J. Pudykiewicz, A. Sirois, E. Voldner, T. Bidleman, and L. Barrie

OBJECTIVE:

To adapt a 3-dimensional tracer model developed by the Atmospheric Environment Service (AES) to the study of the movement of atmospheric contaminants on a hemispheric scale and their exchange between the atmosphere and the earth's surface.

RATIONALE:

It is becoming increasingly apparent that to understand the source of many potentially toxic substances in a particular region of the globe (such as the Great Lakes watershed or the Arctic) the problem must be studied from at least a hemispheric perspective. Because many of these substances have a lifetime in the atmosphere longer than 5 days, a substantial portion of material released at any particular time travels beyond continental boundaries. Their pathways are not only governed by transport processes but by chemical transformation and interaction with the earth's surface.

In any study of pathways, models that simulate these complex processes serve to (i) organize the available information in a quantitative way, (ii) assist in experimental design, and (iii) assess the origin of a substance found in a receptor. In other words, they are a key component of any research on toxic substances.

The model used in this study was developed by the AES in 1987-1990 and was used for assessment of environmental impact of several major environmental disasters (Chernobyl accident, Kuwaiti oil field fires, and volcanic eruptions). The present version of the model is a sophisticated computer system consisting of the 3-dimensional eulerian dispersion model simulating transport processes and numerical weather prediction models providing information about the state of the atmosphere. The dispersion model is based on a system of the advection diffusion equation transformed to the terrain-following coordinate system in order to incorporate the effects of topography.

The model is capable of moving substances around the Northern Hemisphere, using observed wind fields, while allowing them to interact with the earth's surface, clouds and precipitation, and to chemically transform. Figure 1 depicts a simulation of the deposition field of strontium-90 72 hours after an underground

explosion in Novaya Zemlya. It shows how quickly and widely pollution can spread after release. The models can be run quite economically with simple parameterization of the processes and prescribed emission scenarios. Further development of the model will provide a unique capability to investigate different problems related to the atmospheric environment. The most important applications of the model will include studies of the transport of various contaminants to northern ecosystems and studies of the atmospheric pathway of organic compounds.

DESCRIPTION:

The model is being modified to address toxic chemical issues and the most recent results in the area of numerical methods are being implemented. The model will be applied during FYs 1992-94 to estimate contaminant input to the Arctic and source/receptor relationships, utilizing emissions inventories generated under the project "Verification of Contaminant Source Data".

RESOURCES:

	1991/92	1992/93
Green Plan AES ($K)	100	50

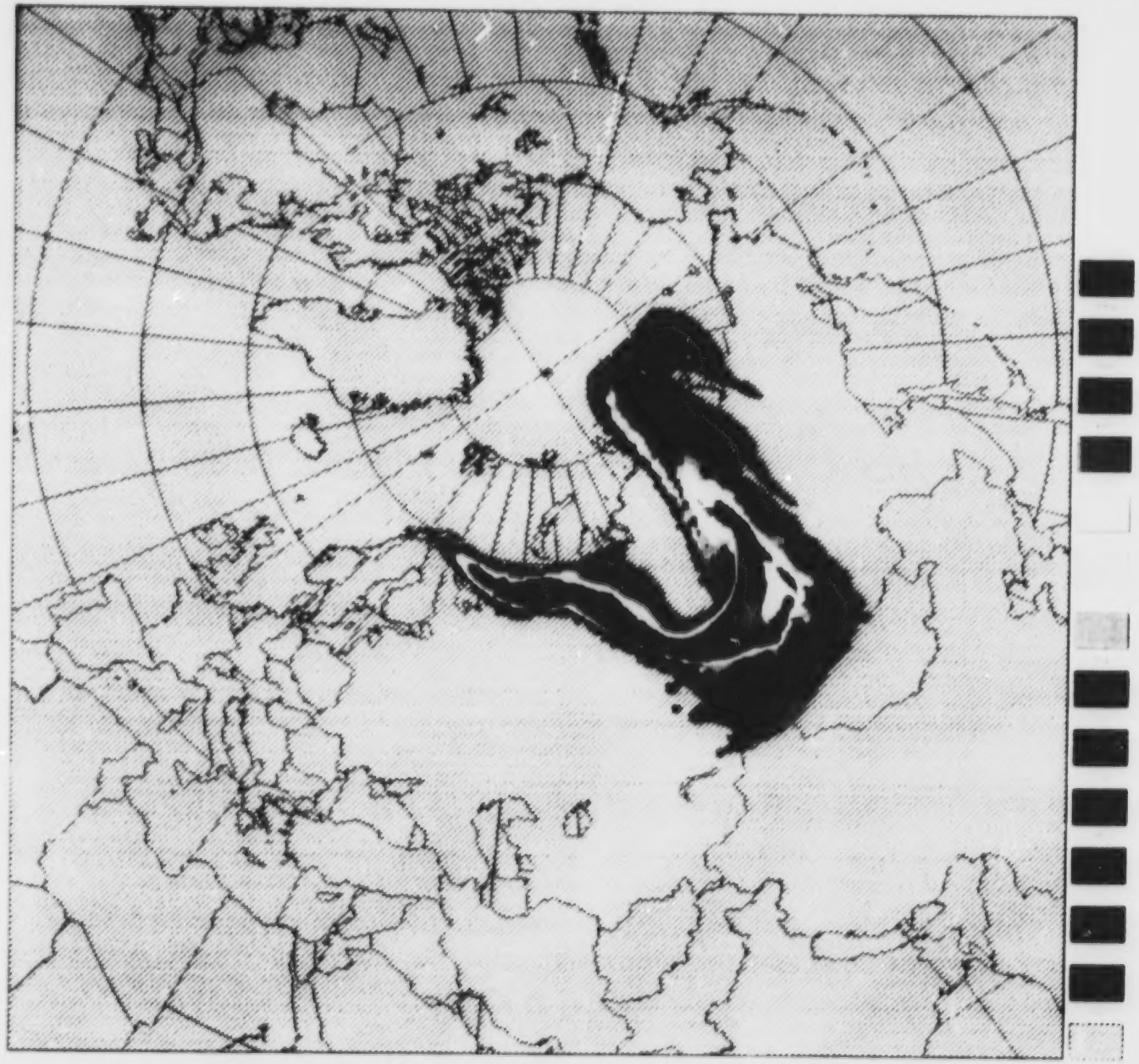


FIGURE 1: Simulation of a Deposition Field of Strontium-90

LONG-RANGE TRANSPORT OF CONTAMINANTS TO THE CANADIAN ARCTIC BASIN

PROGRAM LEADERS: R. Macdonald, F. McLaughlin, Fisheries and Oceans Canada

PROJECT TEAM: R. Macdonald, F. McLaughlin, AXYS Environmental Systems Ltd. (contractor)

OBJECTIVES:

1. To provide a preliminary data set for organochlorine concentrations in air, water, and sediments from Canada's western arctic shelf and basin.

2. Ultimately, to develop a time series for organochlorine concentrations at a deep station in the Canada Basin of the Arctic Ocean.

3. To focus on organochlorine concentrations in the water column according to source of water mass and time since ventilation.

DESCRIPTION:

Introduction

The long-range transport of organochlorine compounds to the Arctic Ocean is well known (Barrie *et al.*, 1992). However, surprisingly few data exist for water-column burdens of these compounds and their fractionation into biota (Hargrave *et al.*, 1988, 1992). This is especially true of the arctic interior water masses. Estimates of source strengths for these compounds indicate that direct atmospheric deposition is important but that other sources, such as inflow through Bering Straits, may contribute the majority of some compounds to the arctic surface waters (Barrie *et al.*, 1992, Hinckley *et al.*, 1991). Therefore, to understand the Arctic Ocean as a sink and as a large-capacity reservoir, which will continue to supply these compounds to marine biota even if the sources are removed, requires study in an oceanographic context. This means not only studying the transfer from atmosphere to ocean within the Arctic Ocean, but also the supply and movement of water masses which are imported from the Pacific, the Atlantic, and from continental runoff.

Since 1987, we have developed a time-series station in the Canada Basin to study interannual variability, vertical flux of particles, water mass structure and current strengths, residence time and age, and ventilation. This station, therefore, provides an ideal oceanographic setting within which to measure and study the distribution of organochlorine contaminants. Conservative behaviour of compounds can be assessed relative to tracers such as

tritium, freons and other standard oceanographic measures. Non-conservative behaviour can be estimated from vertical particle fluxes (sequential sediment traps) and from sediment inventories in the deep waters of the Canada Basin. Sediment inventories can be calculated from contaminant profiles in cores; where sedimentation rates are sufficiently high and biomixing of sediments low, contaminant chronologies can also be determined (e.g. Macdonald *et al.*, 1992). Due to low sedimentation rates, it is unlikely that the Arctic basin sediments will provide industrial contaminant chronologies (the past 50-100 years). However, shelf and nearshore sediments may provide these records, and may actually be the most important sites for removal of contaminants in arctic surface waters.

Activities in 1991/92

As part of a ship-borne cruise, we collected dissolved (XAD columns) and particulate (GF/C filters) water column samples (top 175 m) using Seastar and Infiltrex pump samplers, and two large-volume air samples (polyurethane foam plugs). We also collected a large box core at Station 44 (2600 m), sectioned it and determined organochlorine contaminants at selected horizons, along with other geochemical parameters (e.g. C, N, metals, pore water). Additionally, we analyzed archived surface sediments from five sites on the Mackenzie Shelf edge (200 m) to provide a spatial context (Figure 1).

Axys analyzed all samples for organochlorine and PCB congeners, and for selected samples measured dioxin, co-planar PCB, and PAH.

RESULTS:

There has not been sufficient time to examine all of the organochlorine and oceanographic data in detail. Organochlorine samples were first analyzed by GC-MS and GC-ECD, and later by high-resolution HR GC-MS which delayed delivery of the data and has provided a lot of information for each sample. We list here (Table 1) ranges of selected organochlorine concentrations.

For the water column, the limited data collected so far suggest that concentrations of major organochlorines (e.g. HCH, HCB) at Station 44 are similar to those determined at the Ice Island (Hargrave *et al.*, 1988). We do not yet have sufficient vertical resolution (only 4 depths were collected) to assign organochlorine distributions according to water mass. However, there appears to be vertical structure in the data, and HR GC-MS reveals a complex distribution of congeners within samples. Such data may yield new insight once we have applied chemometry to them. Of the dioxins, only OCDD was detected in the dissolved portion. The oceanographic data have not yet been interpreted in the context of water masses and ventilation.

The sediment data suggest that deep basin sediments are probably not an important sink for these contaminants. This may be due to low productivity and hence low vertical particulate fluxes in this region (Macdonald and Carmack, 1991). However, these data do provide a basis to delimit organochlorine loss by sedimentation in the Arctic interior ocean. In contrast, the shelf sediments appear to contain greater organochlorine concentrations. Since shelves have greater sedimentation rates than the deep basins, the shelves may provide an important sink which cannot be neglected in Arctic Ocean - Organochlorine models. We have a good, complete PAH sediment data set from which we should be able to distinguish between atmospheric (pyrogenic) PAH and river derived PAH as has been done in earlier work centred on the Mackenzie Shelf (Yunker *et al.*, 1992).

We have collected only 2 air samples; we have too small a data set to give us confidence in discussing the results.

CONCLUSIONS AND FUTURE DIRECTIONS:

There does not exist a time series for organochlorine concentrations in Arctic Ocean interior waters. Therefore, it is a high priority to collect further profiles at the Canada basin station over time, and to attempt to make these measurements with good oceanographic vertical resolution. Only this will allow us to resolve whether Arctic Ocean burdens are increasing with time, and whether lateral or air-sea transport is regionally more important. To determine the importance of lateral transport we need more data for the Chukchi Sea where Pacific water enters the Arctic Ocean.

In addition to the parameters measured this year, it is clear that toxaphene ought to be added to the list (e.g. Bidleman *et al.*, 1989; D. Muir, pers. comm.).

A gap presently exists in the geographic distribution of samples/data for the Arctic. Measurements of organochlorines have been made or are planned to be made for the Arctic interior ocean (Hargrave *et al.*, 1988, 1992, this study), for rivers (D. Gregor, pers. comm.), for arctic lakes (Muir *et al.*, 1992) and for snow (Gregor and Gummer, 1989). Yet we lack nearshore (shelf and estuary) measurements needed to determine the importance of shallow, shelf regions for scavenging organochlorines to sediments. Estuaries are important to the Arctic biologically and as a source for country foods. In addition to atmospheric and ocean derived contaminants, estuaries receive an added burden from runoff (rivers, snow melt). To provide these measurements we plan to sample in Liverpool Bay/Husky Lakes region and collect water, biota and sediment. It should be noted that belugas, which were trapped here during freeze-up, have been found to contain organochlorines in their fat (Muir, pers. comm.).

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Figure 1: Oceanographic Sampling Locations in the Beaufort Sea.

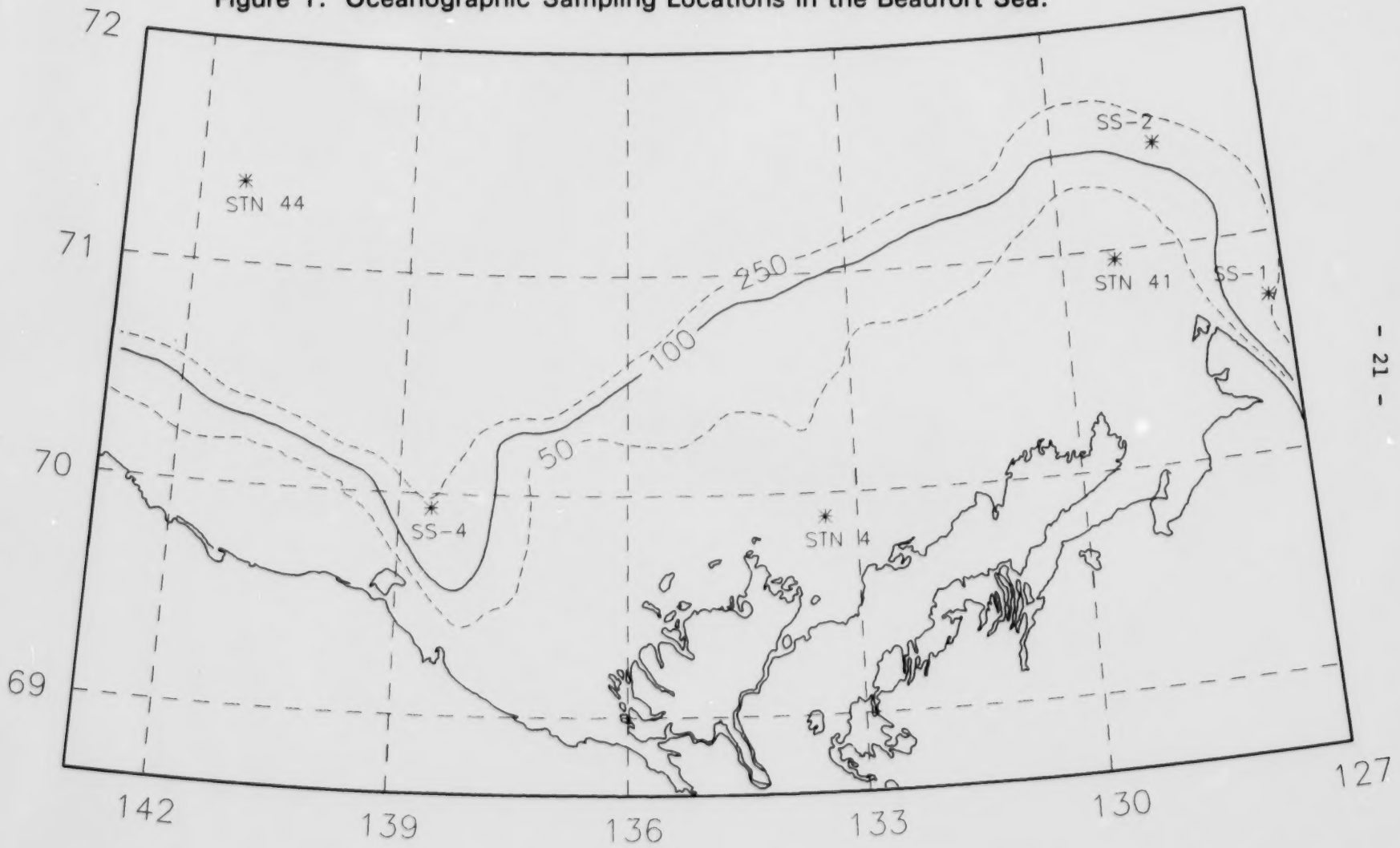


TABLE 1 RANGES OF CONCENTRATION FOR SELECTED COMPOUNDS.

	SEDIMENT SHELF ng/g	SEDIMENT BASIN ng/g	DISSOLVED pg/L	PARTICULATE pg/L
HCB	0.24-0.78	0.11	16-20	ND-0.29
αHCH	0.1-1.7	0.04	1100-4100	ND-3.0
γHCH	0.01-0.15	0.005	450-810	ND-0.32
trans-Chlordane	ND	0.02	ND-(1.7)	ND
cis-Chlordane	ND-(0.26)	(0.09)	ND-3.7	ND
PCB 105	(0.002)-0.006	0.004	0.5-3.8	0.15-0.58
PCB 138	(0.002)-0.01	0.02	1.4-6.2	0.37-2.1
PCB 153	(0.008)-0.01	0.02	0.8-4.9	0.37-2.8
	pg/g	pg/g	fg/L	fg/L
PCB 77		2.4		ND
OCDD	2.8-7.5	ND	98-140	ND

ND (not detected)
(###) peak detected, not quantified

PCB nomenclature
77 (3,3', 4,4' TCB)
105 (2,3, 3',4, 4' PCB)
138 (2,2',3,4,4',5' HCB)
153 (2,2',4,4', 5,5' HCB).

CURRENT CONTAMINANT DEPOSITION MEASUREMENTS IN PRECIPITATION

PROGRAM LEADER: D. J. Gregor, National Water Research Institute, Environment Canada

PROJECT TEAM: A. Redshaw, Chief, NWT Programs, Inland Waters Directorate, Yellowknife;
G. Whitley, Administrator, Pollution Control, Water Resources Division, Indian and Northern Affairs, Whitehorse;
Atmospheric Environment Service (Winnipeg, Mould Bay, Eureka, Resolute Bay)

OBJECTIVES:

Short Term

i) To quantify annual deposition of trace organic contaminants to the Canadian north through the establishment of a multi-station sampling network.
ii) To develop methods capable of assessing seasonal and event deposition of contaminants at selected intensive sampling sites co-located with several of the annual deposition stations.
iii) To determine spatial variability in contaminant deposition and assess short term trends.

Long Term

i) To demonstrate the use and assist in the design of a snow chemistry monitoring program for the Canadian North.
ii) To use this information as input to a deposition, transport, and loadings model which together with the results from the intensive basin studies will be used for the estimation of contaminant loadings to the arctic marine coastal zone.
iii) To assist in the calibration of the AES-DOE emission, atmospheric transport and deposition model for pesticides.

DESCRIPTION:

The network of annual snowpack sampling locations was initiated in part in 1990 and continued in 1991 and will again be expanded in 1992 (Table 1). Samples will be collected annually through arrangements with IWD-NWT, DIAND (NWT and Yukon), GNWT and AES-DOE (selected weather stations). Sample collection begins in April of each year in the Yukon and southern Mackenzie and gradually proceeds to the east and north with completion in the High Arctic in May. Samples are carefully collected into specially constructed aluminum containers and sealed until melted and extracted in the north. While samples are collected by a number of people, all

samples are extracted and analyzed by NWRI. Detailed field sheets are filled out at each site. A rigid protocol for preparation of sample containers and sampling equipment has been developed in the field. A total of 10 spikes are added to each sample beginning with a field spike and continuing through all aspects of extraction and clean-up in order to measure any losses in the sample between the time of collection and analyses.

In addition to the annual snowpack samples, large volume snow collectors were operated at Eureka and Mould Bay from October, 1990 to March, 1991 and are again in operation during the winter of 1991/92. A third snow collector, complete with a remote automated weather station was installed near Whitehorse in December, 1991. All bulk snow samples and collector samples for the winter of 1991/92 have been analyzed for OCs and PCBs and extracts have been retained for subsequent toxaphene analysis upon acceptance of a method.

During FY 1991/92 we have been able to formalize the procedures for collection of bulk snow samples with the design and construction of special purpose sample containers. Field sampling kits have also been prepared and have been distributed throughout the NWT so that IWD and DIAND staff have a uniform set of equipment with which to collect the samples. The broad spatial coverage that we are achieving would not be possible without the extensive support of IWD-NWT Programs office in Yellowknife, DIAND district offices and the ongoing support of Polar Continental Shelf Project (PCSP), Resolute Bay. The laboratory facilities at PCSP have been upgraded to now include a quality ventilation cabinet through a joint project between NWRI and PCSP.

Preliminary data for selected compounds for the Mould Bay collector are shown in Figures 1 and 2. These results show several things of interest. First, there was a gradual increase in contaminant deposition peaking in January followed by a decline until collection terminated in March due to technical problems at the site. Second, the PCB deposition is dominated by the lower chlorinated compounds. This can likely be explained by the fact that the heavier compounds are more likely to be particle associated and therefore are deposited closer to the source. Finally, there is a noticeable contrast between the total deposition of organochlorine pesticides and PCBs as measured by the sum of the snow collector samples and the total deposition as measured in the bulk snow sample. For the more volatile, predominantly gaseous state pesticides, the snowpack samples have a much lower deposition rate than the sum of the collector samples suggesting re-volatilization of these compounds from the snowpack. In contrast, the PCBs deposition rate calculated for the snowpack exceeds that determined from the snow collector suggesting that PCBs continued to be deposited after the snow collector was terminated and were not lost from the bulk snow.

The analytical results from the bulk snow samples have not been fully synthesized at this time but will be considered in context of

earlier data during the forthcoming year.

UTILIZATION OF RESULTS:

The large volume snow collector data will serve to evaluate the ability of the snowpack samples to characterize annual deposition to arctic sites. As well, timing of deposition of contaminants and thus linkages to major air masses and source trajectories will be possible. While the design and efficiency of the collectors is still being assessed, it is possible that these collectors will be accepted in other areas of the Arctic with low snow fall and thus can be employed as part of the circumpolar Arctic Monitoring and Assessment Program. Snowfall collectors for high snowfall areas are also being developed and tested outside of this study. The determination of the fate of these contaminants during the spring season leading up to snow melt is essential to monitoring and modelling the fate of these contaminants in the aquatic system. A better, and more rapid assessment of the fate of semi-volatile contaminants deposited to the snowpack will be achieved through the development of the arctic simulation laboratory which will permit more detailed characterization of contaminant re-volatilization from the snow and the fate upon snowmelt.

RESOURCES:

	91/92	92/93	93/94	94/95	95/96	96/97	Total
AES	(received)		(requested)				
PYs*	0.2	0.3	0.3	0.3	0.3	0.3	
Sal	14	21	21	21	21	21	119
O&M	20	80	125	100	100	100	570
Total $K	34	101	146	121	121	121	689

* PYs and salary dollars have already been allocated directly to the department but have been shown here to provide a complete record of AES support for the study.

Other (total estimated dollar value of direct and indirect contributions)

	91/92	92/93	93/94	94/95	95/96	96/97	Total
IWD/NWRI	70						
IWD-YKF	10						
DIAND	10						
PCSP	15						
AES	15						
Total $K	120						

LIST OF STATIONS SAMPLED IN NWT AND YUKON SNOW SURVEY

Western and Central Arctic	1990	1991
Peel River above Ft. Mcpherson (67° 13'N 134° 57'W)	X	
Nahanni River near Nahanni Butte	X	
Great Bear River at outlet of Great Bear Lake (65° 8'N 123°31'W)	X	
Great Bear Lake near Echo Bay		X
Ellice R. near mouth (67° 42.5'N 104° 8.5'W)	X	X
Akasta River	X	X
Thonokied River	X	
Cameron river below Reid Lake (62° 29'N 113° 31'W)	X	X
Kakisa River	X	
Mackenzie River near Ft. Good Hope		X
Keewatin Arctic		
Baker Lake (VOR Lake) (64° 18'N 96° 5'W)	X	X
Yathkyed Lake (62° 42'N 98° 18'W)]	X	
Hayes River (67° 32'N 94° 5'W)	X	X
Back R. below Deep Rose Lake (66° 5'N 96° 30'W)	X	
Brown River (66° 2'N 91° 50'W)	X	
Thelon River above Thelon Bluffs (64° 32'N 101° 24'W)	X	X
Lorillard River (64° 15'N 90° 26'W)		X
High Arctic		
Stanwell Fletcher Lake, Somerset Island	X	X
Lake Hazen, Ellesmere Island	X	
Agassiz Ice Cap, Ellesmere Island (80° 40'N 73° 30'W)	X	X
Unnamed lake near Resolute Bay (74° 42'N 94° 54'W)	X	X
Mould Bay, Prince Patrick Island (76°15'N 119° 16'W)	XC*	XC
Eureka, Ellesmere Island (80°00'N 86°36'W)	XC	XC
Alert, Ellesmere Island	X	
Lady Melville Lake (68°38'N 92°30'W)	X	X
Chartrand Lake (near Spence Bay)	X	X

* Indicates that a large volume snow collector was operated in addition to the collection of snowpack samples.
Note: a number of sites were missed in 1991 due to a lack of funds at the end of FY 1990/91 (sampling had to be done in March in the west) as well as to weather problems in the Keewatin. Also, stations such as Lake Hazen and Alert are collected only as opportunities permit due to the high cost.

Figure 1a: Time series of HCH flux to the Mould Bay snow collector from October 26, 1989 to March 1, 1991. The total deposition to the collector is compared to the total deposition measured in a triplicate snowpack sample collected at Mould Bay on May 1, 1991. Despite the longer period of deposition for the snowpack sample, it represented only 19 and 29 % of the deposition to the collector for alpha-HCH and lindane, respectively. This is attributed to the revolatilization of these contaminants from the snow to the atmosphere during the late winter. The snow collector data have not been corrected for over or under catch as a result of wind.

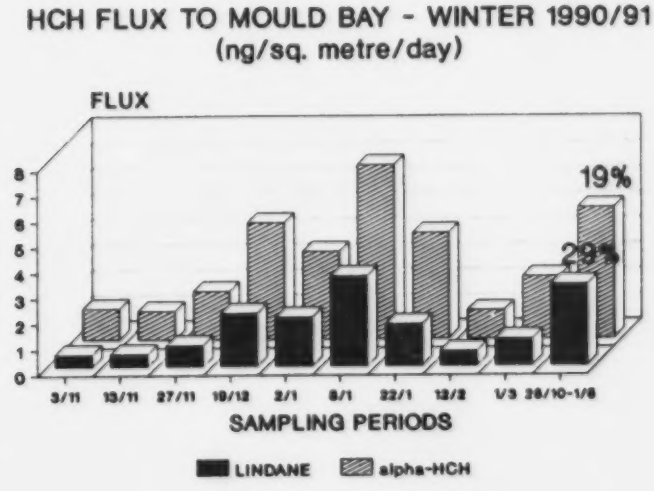


Figure 1b: The total flux for selected compounds measured for the snow collector during 117 days of operation compared to the total flux as determined from triplicate snowpack samples representing 186 days of accumulation. As with HCHs above, this difference represents contaminant revolatilization during late winter. (TTCB = tetrachlorobiphenyl, HCB = hexachlorobenzene, dield = dieldrin, g-chlor = gamma chlordane)

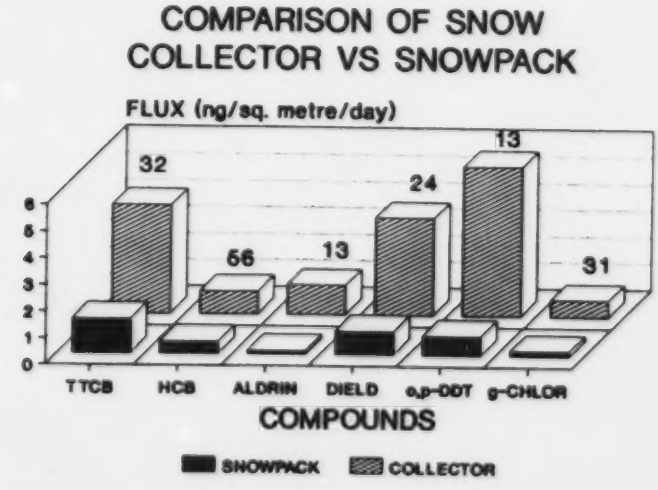
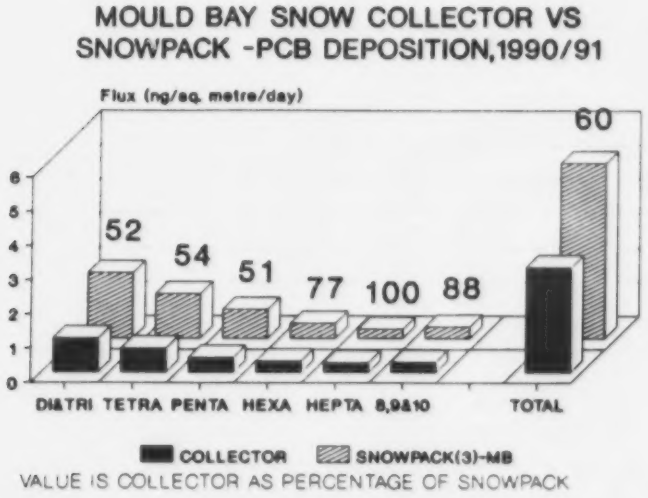


Figure 2: Distribution of PCB congeners comprising the total deposition to the snow collector (over 117 days) compared to that measured in the triplicate snowpack sample representing 186 days of accumulation. Note the dominance of the lower chlorinated PCBs and the fact that the snowpack shows a much higher flux rate than the collector for all PCBs in contrast to the pesticides in Figure 1. This indicates a trend of reduced revolatilization of PCBs to the atmosphere in the late winter as the number of chlorines increase.



OCCURRENCE AND DISTRIBUTION OF BLACK CARBON PARTICLES AND POLLEN AT ALERT, NWT

PROJECT LEADER: L.A. Barrie

PROJECT TEAM: J.P. Smol and N. Doubleday

OBJECTIVES:

To investigate the morphology, distribution and abundance of black carbon particles and pollen grains in lake sediment, air and snow samples at Alert, NWT, and at other sites for comparative purposes, using paleoecological techniques to develop the historical record of black carbon and pollen occurrence, thereby contributing to better resolution of possible source areas for black carbon particles and related contaminants.

PROJECT DESCRIPTION:

Paleoecological studies can contribute to arctic contaminants research by providing baseline data on a chronological basis which is invaluable for monitoring and assessing environmental change, and that would otherwise be unobtainable (Barrie *et al.* 1985). For example, paleoecological approaches to studies of pollutants in ice and snow in the Arctic have been successful in identifying early occurrences of anthropogenic contaminants such as lead (Alderton 1985). The objectives of the project are to describe the occurrence of black carbon particles, such as charcoal and soot, and of pollen grains, in the High Arctic; and to assess their usefulness as indicators of source areas for long-range transport. Anthropogenic black carbon particles are known to be associated with the occurrence of contaminants such as mercury, lead, and polycyclic aromatic hydrocarbons (PAH) (Alderton 1985; Wickstrom and Tolonen 1987), and a primary objective of this research is to assess their potential as surrogates for toxic contaminants in studies of transport and deposition in the Arctic. In addition, black carbon particles are particularly important in the arctic environment because of their ability to influence the atmospheric energy budget through changes to the net amount of solar radiation trapped in the troposphere, and also at the surface of the snow (due to reduced albedo), and hence to affect climate (Barrie 1986). For these reasons, knowledge of the distribution and abundance of black carbon particles resulting from this project may also benefit research on climate.

Pollen grains deposited in the Arctic may be derived from local or regional flora, and also transported over long distances from flora outside the region. Pollen from species which do not occur in the Arctic is termed "exotic" and can be used as an indicator of long-range transport, and of paleowind patterns (Bourgeois 1985; Fredskild 1984). As it is possible to determine the identity of

pollen grains to genus and in some cases to species, pollen provides a potentially useful indicator of air mass movement, linking regions of pollen origin with regions of pollen deposition. The long-term objective of this project is to integrate paleoecological studies of the spatial and temporal distribution and abundance of anthropogenic black carbon particles, pollen and charcoal in lake sediment, air filter and snow samples, and to compare these findings with known contaminant profiles, such as PAHs, in order to assess the usefulness of these particles as surrogates for contaminant transport and deposition.

ACTIVITIES IN FY 1991/92 (January - September 1992):

1) Sampling: A sampling grid has been identified with a north-south transect running from Alert to Sannikiluaq, an east-west transect following the DEW line, and a second east-west transect running through the Queen Elizabeth Islands. Samples of a number of high and mid-arctic lake sediment cores have been obtained by the project team courtesy of L. Lockhart (DFO) and G. Brunskill (formerly of DFO). F. Hopper and L. Barrie (AES) kindly agreed to make air filter samples available. S. Edlund (EMR) and M.K. Woo (McMaster) have provided snow filter samples. R.M. Koerner and J. Bourgeois (EMR) have agreed to provide snow samples. D. Gregor (NWRI) has offered assistance in collecting samples, and K. Reimer (RRMC) has agreed to provide soil and other samples from DEW line sites. All of this support is gratefully acknowledged. In addition, samples of air filters, water, sediment, soil and vegetation were collected by the project team during the past summer from 15 sites on Cornwallis Island and from 15 sites in the vicinity of Alert, NWT on N. Ellesmere Island.

2) Analysis: Methods for black carbon particle (Rose 1990) and pollen analysis (Bourgeois 1985, and Fredskild 1984) have been tested using artificial and natural samples, and applied to samples from the Belcher Islands.

RESULTS:

This is a multi-year project scheduled for completion in September 1995 and only preliminary findings are available. Preliminary investigations of sediments from the Hazen and Belcher sites confirm the feasibility of the methods by providing evidence of black carbon and pollen. At Hazen, it is clear that windblown coal presents a problem for analysis which must be resolved before work at this and at similar sites which are exposed to deposition of coal dust can be completed. The influence of windblown coal at Hazen and Buchanan further emphasizes the importance of the sites near Alert.

Preliminary results available for the Belchers indicate that shallow ponds are useful for sediment studies of black carbon and pollen, as well as diatoms (Moser, Douglas, Doubleday and Smol

1992). The cores obtained from these shallow ponds are relatively short (approximately 24 cm long) and are expected to be quite recent based on rates of isostatic rebound found in the literature. However reliable dates are needed before a definitive evaluation of these shallow ponds as sources of recent sediments in relation to deeper arctic lakes can be made.

Documentation of particle morphology has begun as the first stage of development of an atlas of particle morphology for black carbon particles and pollen grains in high arctic air, lake sediment and snow samples.

Expected project completion date: September 1995

Partners: L. Lockhart and D. Muir (DFO); G. Brunskill (formerly DFO); S. Edlund, R. Koerner and J. Bourgeois (EMR); M.K. Woo (McMaster U.); F. Hopper (AES); K. Reimer (RRMC); J. Poland (Queen's U.); D. Gregor (NWRI); D. Stone (DIAND); Inuit Circumpolar Conference

Additional sources of project support:

1991/92
Queen's University - Dean's and Graduate Student Awards (N. Doubleday)
Arctic Institute of North America - Lorraine Allison Scholarship (N. Doubleday)
AES/DOE Contract
AES/NSERC Subvention Grant
DIAND - Northern Training Grant
Polar Continental Shelf Project
DND - CFB Alert
Carleton University - K. Torrance, Dept. of Geography

SEPT 1992- SEPT 1995
SSHRC/NSERC/MRC - Eco-Research Doctoral Fellowship (N. Doubleday)

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SOURCES AND SINKS OF ORGANOCHLORINES IN THE ARCTIC MARINE FOOD WEB

PROGRAM LEADER: B. Hargrave, Habitat Ecology Division, Biological Sciences Branch, Fisheries and Oceans Canada

PROJECT TEAM: G.A. Phillips, R.J. Conover, H. Welch

OBJECTIVES:

1. To measure seasonal levels of 16 organochlorine residues (including PCBs and toxaphene) in snow, seawater, under-ice epontic particulate matter, pelagic and benthic crustaceans, fish and sediments in arctic marine areas with different levels of biological productivity.

2. To compare a database for organochlorine residues in the arctic marine environment collected from the Ice Island (1986-1991) over the continental shelf of the Arctic Ocean with data from Resolute Bay-Barrow Strait regions (to be initiated in 1992) to model bioaccumulation of organochlorines in marine organisms from lower trophic levels as a function of seasonal changes in marine biological productivity and organism lipid composition.

DESCRIPTION:

Introduction

Organochlorines, such as PCBs, DDT, chlordane and toxaphene, are present in diets of northern populations due to global redistribution processes. Organochlorines enter the arctic marine food web from atmospheric and ocean sources and they are concentrated in lipid-rich tissues of marine invertebrates and vertebrates. Pathways leading to this bioaccumulation are poorly described and rates of transfers have not been measured. Seasonal differences in bioaccumulation can be expected due to changes in marine food web productivity, organism feeding and growth rates and lipid metabolism. Measurements of absolute and relative concentrations of organochlorines can be used to infer sources and, by comparison with earlier studies, detect temporal changes.

Major semi-volatile chlorinated organic compounds were measured in the Canadian high arctic marine environment and lower levels of the marine food web by sampling snow, seawater (dissolved and particulate phases), zooplankton, benthic crustaceans, fish and sediments from the Canadian Ice Island (1986-1990) (Bidleman *et al.* 1989; Hargrave *et al.* 1988, 1989, 1992). The data provides a baseline for concentrations of organochlorines in Arctic Ocean waters and lower trophic level organisms over the continental shelf

off Canada's northern coast against which future observations in Barrow Strait and Resolute Bay will be compared.

Activities in 1990/91

Observations of 16 organochlorine pesticides, PCBs and toxaphene, determined in pelagic and benthic crustacean fauna collected from the Canadian Ice Island between 1986 and 1989, were collated and summarized in a primary publication (Hargrave *et al.* 1992). No new field work was carried out during 1991. A data report summarizing results from a 4-laboratory intercalibration of organochlorine residues in biota was prepared for publication as a DFO Data Report (Phillips 1992). Greater than 67% of organochlorine determinations by SeaKem, Freshwater Institute and BIO laboratories were similar with the least similar results reported for α-HCH, PCBs and toxaphene.

RESULTS:

PCBs, toxaphene and isomers of DDT and DDE were the predominant organochlorines measured in epontic particulate matter, zooplankton, pelagic and benthic amphipods, and liver tissue from a glacial eelpout (*Lycodes frigidus*) collected at 79° N of Axel Heiberg and Ellef Ringnes Islands and 85°N over the Alpha Ridge in the Arctic Ocean. The results are summarized in Hargrave *et al.* (1992).

Chlordane, dieldrin and other cyclodienes and hexachlorocyclohexane (HCH) isomers were present in tissue of all organisms at lower concentrations. Organochlorine concentrations in planktonic crustaceans between <63 μm to 2 mm on a dry weight basis were similar to those in epontic particulate matter. On a lipid weight basis, concentrations in plankton were from two to five times higher. Organochlorines in amphipods and *Lycodes* liver exceeded levels in plankton by up to an order of magnitude. Large benthic lysianassid amphipods (*Tmetonyx cicada, Anonyx nugax* and *Eurythenes gryllus*) accumulated higher concentrations (up to 20 ppm g^{-1} lipid) than small species (*Onisimus spp.* and *Andaniexis spp.*) or the under-ice amphipod *Gammarus wilkitzkii*).

No significant differences in organochlorine concentrations were measured in benthic amphipods collected at different times between May and September in various years. However, concentrations in lipids of small zooplankton (<63 μm) decreased between May and August. Large zooplankton (>500 μm) collected in August, dominated by adult copepods (*Calanus hyperboreus* and *Calanus glacialis*) and ctenophores (*Oikopleura vanhoeffeni* and *Beroe cucumis*), contained concentrations of α-HCH, chlordane isomers and other cyclodienes that were two to four times higher than levels in May. Biomagnification factors calculated for presumed predator-prey links in the food web varied over two orders of magnitude for different organochlorines. Ratios between epontic particulate

matter and plankton (<10) were generally lower than values for trophic links between amphipods, and previously published concentrations in arctic marine fish and mammals (10-100).

CONCLUSIONS AND FUTURE DIRECTIONS:

Monitoring of semi-volatile organochlorines in air, snow, ice, seawater and planktonic and benthic crustaceans using the Canadian Ice Island has shown that PCBs, toxaphene, hexachlorobenzene (HCB), isomers of hexachlorocyclohexane, DDT and chlordane are present in all environmental samples with concentrations increased in lipids of biota. All of these contaminants have been detected at more southern latitudes but concentrations in the Arctic Ocean for each sample type are among the lowest recorded for any ocean area. However, bioconcentration of some organochlorines (chlordane, toxaphene, PCBs) in planktonic copepods and benthic crustaceans reached ppm levels in lipids, similar to values found in arctic marine mammals (Muir *et al.* 1988). These compounds were present in very small amounts in air and seawater collected from the Ice Island but their solubility in lipids and the seasonal accumulation and synthesis of fat by lower trophic levels of the arctic marine food web results in bioaccumulation. PCBs, DDT and chlordanes are magnified in the arctic marine food web to a far greater degree than more abundant compounds such as HCHs and HCB that have a higher water solubility.

Plans for 1992/93 and subsequent years are to extend investigations of levels of organochlorines in lower trophic level marine organisms to Arctic marine waters that have higher levels of biological productivity than were sampled under semi-permanent ice-cover from the Ice Island. Seasonality in biomass production and the accumulation of lipids should be pronounced in waters of Barrow Strait and Resolute Bay and the impact of changes in lipid production, storage and metabolism on levels of organochlorines in planktonic and benthic invertebrates will be monitored. A 12-month over-wintering study (POLARPRO) is proposed to be carried out using DFO facilities (South Camp) at Resolute Bay co-ordinated by Dr. H. Welch (DFO, Winnipeg). This will permit sampling from ice formation in the fall of 1992 throughout the winter, spring and summer seasons. No previous study has provided seasonal data over a full annual cycle for contaminants in any arctic ecosystem. Collaboration with D. Gregor (DOE, Burlington) (organochlorine input through snowfall) and L. Barrie (DOE, Downsview) (air sampling) will allow mass balance calculations to determine the relative importance of atmospheric vs. oceanic organochlorine input to lower trophic levels of the marine food web.

Partners: Two private laboratories (Axys, OceanChem) and two DFO laboratories (BIO, Freshwater Institute) were involved in the inter-laboratory comparison of measurements of organochlorines. Field work was carried out with the assistance of Polar Continental Shelf Project of Energy, Mines and Resources Canada.

RESOURCES: (received in 1991/92, 1992/93 and planned under the Green Plan AES)

	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
$K	12	72	77	84	87.5	82

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TABLE 1: AMITUK LAKE SUMMARY CHEMISTRY DATA

Field measurements	Surface Water(38.0 L)	Surface Water(38.1 L)	Bottom Water(38.2 L)	Snow #1 of 2 (34.5 L)	Snow #2 of 2 (36.3 L)
pH	8.2	8.2	8.2	6.65	6.65
Conductance (µsie/cm)	78	78	78	13.3	13.3
temperature (°C)	1.5	1.5	1.5		
Laboratory Measurements					
pH					
Conductance (µsie/cm)		8.03	8.02	6.38	6.43
Total dissolved solids (mg/L)	8.09	144	175	13.8	14.4
	153	73	91	6	6
Nutrients (mg/L)	77				
Nitrogen-dissolved					
Nitrogen-particulate		0.046	0.232	0.036	0.040
Diss NO2+NO3 as N	0.048	0.013	0.033	L0.01	L0.01
Nitrogen-total as N	0.016	0.022	0.178	0.034	0.034
Carbon-partic. organic	0.018	0.06	0.27	0.05	0.05
Carbon-diss. organic	0.06	0.030	0.151	0.028	0.043
Carbon-organic total	0.034	0.314	0.328	NV	L0.1
Phosphorus-particulate as P	0.361	0.34	0.48	NV	0.14
Phosphorus-total dissolved	0.4	L0.006	L0.006	L0.006	L0.006
Phosphorus-dissolved ortho-P	L0.006	0.0013	0.0009	0.0014	0.0007
Phosphorus-total	0.0012	0.0004	0.0006	0.0003	NV
	0.0004	0.0018	0.0042	0.0014	0.0052
Ions (mg/L)	0.0030				
Alkalinity-ttl. as CaCO3					
Calcium-dissolved		69.6	85.5	1.7	1.5
Magnesium-dissolved	71.2	21.3	26.1	0.61	0.57
Fluoride-dissolved	22.7	3.9	4.6	0.27	0.21
Potassium-dissolved	4.2	0.02	0.03	L0.01	L0.01
Sodium-dissolved	0.03	0.19	0.20	0.07	0.08
Chloride-dissolved	0.19	1.7	1.7	1.2	1.3
Silica-reactive as SiO2	1.6	2.7	2.9	2.3	2.6
Sulphate-dissolved	3.0	0.28	1.66	L0.02	L0.02
Bicarbonate	0.33	1.3	1.4	0.3	0.6
Hardness-total as CaCO3	1.8	84.8	104.2	2.1	1.8
Non-carbonate hardness	86.8	69.2	84.1	2.6	2.3
	74	0.0	0.0	0.9	0.8
Metals (mg/L)	2.8				
Aluminum-total		0.008	0.018	0.015	0.012
Barium-total	0.008	0.0044	0.0065	0.0005	0.0007
Cadmium-total	0.005	L0.0001	L0.0001	L0.0001	L0.0001
Chromium-total	L0.0001	L0.0002	0.0003	L0.0002	L0.0002
Cobalt-total	L0.0002	L0.0001	L0.0001	L0.0001	L0.0001
Copper-total	L0.0001	0.0010	0.0026	0.0031	0.0031
Iron-total	0.0024	0.0066	0.0091	0.0137	0.0136
Lead-total	0.0023	0.0054	L0.0002	L0.0002	L0.0002
Lithium-total	0.0003	0.0004	0.0005	0.0001	L0.0001
Manganese-total	0.0003	0.0002	0.0003	0.0004	0.0004
Molybdenum-total	0.0001	L0.0001	L0.0001	L0.0001	L0.0001
Nickel-total	L0.0001	L0.0002	L0.0002	0.0004	0.0003
Strontium-total	L0.0002	0.0592	0.0832	0.0026	0.0027
Vanadium-total	0.0627	L0.0001	0.0001	L0.0001	L0.0001
Zinc-total	L0.0001	L0.0002	L0.0002	0.0019	0.0088
	0.0007				
Trace Organics (ng/L)					
Hexachlorobenzene		0.07	L0.07	L0.07	L0.07
p,p'-DDT	L0.07	L0.28	L0.28	L0.28	L0.28
o,p'-DDT	L0.28	L0.26	L0.26	L0.26	L0.26
p,p'-TDE	L0.26	L0.22	L0.22	L0.22	L0.22
p,p'-DDE	L0.22	L0.2	L0.2	L0.2	L0.2
Methoxychlor	L0.2	L1.6	L1.6	L1.6	L1.6
Heptachlor	L1.6	L0.11	L0.11	L0.11	L0.11
Heptachlor epoxide	L0.11	0.04	0.04	0.04	L0.03
α-Endosulfan	0.03	0.02	L0.01	0.09	L0.01
ß-endosulfan	L0.01	L0.09	L0.09	L0.09	L0.09
α-chlordane	L0.09	L0.01	L0.01	L0.01	L0.01
γ-chlordane	L0.01	0.01	0.01	L0.01	L0.01
	0.01				
α-HCH		3.35	2.22	0.11	L0.1
γ-HCH (lindane)	3.27	0.42	L0.40	L0.1	L0.1
Dieldrin	0.45	0.05	0.09	0.22	0.12
1,4-Dichlorobenzene	0.05	1.71	1.61	7.13	6.81
Pentachlorobenzene	4.34	L0.05	L0.05	0.05	L0.05
1,3-Dichlorobenzene	L0.05	L0.5	L0.5	0.91	0.77
	0.5				

PROCESSES AND FLUXES OF CONTAMINANTS IN AQUATIC SYSTEMS

PROGRAM LEADERS: R. Semkin and D. Gregor, National Water Research Institute, Environment Canada

PROJECT TEAM: J. Carey, D. Jeffries and R. Rowsell, National Water Research Institute;
A. Redshaw, Inland Waters Directorate-NWT, Yellowknife;
T. Prowse and J. Pomeroy, National Hydrology Research Institute, Saskatoon

OBJECTIVES:

Short Term

i) To establish an experimental basin in the High Arctic for the purpose of determining a detailed hydrologic and contaminant budget for the basin.
ii) To measure in an intensive manner within the basin the hydrology and the flux of organic contaminants and specific ions especially during the winter accumulation and snow melt seasons.
iii) To investigate and quantify the major processes affecting contaminant transformation, transport and fate in each basin in order to provide predictive capability for basin mass balances.
iv) To develop and calibrate contaminant transport models utilizing the results from this basin study and to compare the results among comparable basin studies (see NHRI proposal for the Mackenzie Valley study).

Long Term

i) To quantify mass balances of contaminants and selected inorganic substances for selected arctic watersheds in the Canadian north.
ii) To investigate and quantify the key abiotic processes controlling contaminant fate and dynamics in arctic freshwater systems.
iii) To utilize the study results from all basins studied in the arctic for model development and calibration in order to estimate contaminant transport and flux in larger northern aquatic systems.

DESCRIPTION:

It is essential to study small basins in detail to characterize how contaminants deposited in the Arctic move through the aquatic system and accumulate in the ecosystem. This project received funding in January, 1992 and immediately an intensive effort was mounted to provide the logistical support necessary to undertake a detailed study of Amituk Lake Basin on east Cornwallis Island. In

anticipation of approximately six staff spending 8 to 10 weeks each undertaking research and routine measurements in this basin during the spring and summer seasons, it was considered essential to provide a semi-permanent field camp. Through a contract to Narwhal Arctic Services Limited, and with assistance from a local Inuit (Mr. Peter Amarualik), a thirty foot accommodation trailer has been leased and transported from Resolute to the Amituk Lake basin, approximately 70 km east northeast of Resolute. Additional facilities that have been purchased and will be installed in May include a generator and year round weather station. The weather station will be used to provide real time information of wind, temperature, snow accumulation and especially incoming and outgoing solar radiation as base information to subsequent modelling efforts. In addition, a crude field laboratory will be constructed at the site for processing of samples and the laboratory facilities at PCSP Resolute were upgraded to support this work. A reconnaissance of the basin was undertaken in March, 1992 and preliminary basin maps have been prepared.

Please note that this lake has previously been studied in part (lake sediments and fish) by DFO-Winnipeg under an earlier AES project. As well, NWRI undertook some preliminary water and snow chemistry work on this lake in conjunction with the DFO study. Snow and water data for Amituk Lake are presented in Table 1. The data suggest that the water chemistry of this basin is quite typical of small riverine systems in the high arctic islands.

The first intensive work in the basin under this study will be in May of 1992 when snow courses for hydrology and snow sampling for ions and organic contaminants will be completed to document mid-winter conditions. The basin will also be mapped and defined using existing air photos. Understanding the hydrologic budget and ion budget is the first step in determining the contaminant budget which does not behave conservatively (i.e. transformations and exchanges can occur with the semi-volatile, photo-reactive trace organic compounds). The chemistry of the lake water column will also be investigated to define the structure of the lake at the end of the winter season and appropriate sampling will be undertaken for organic contaminants.

The basin will be re-visited by a team from NWRI from approximately mid-June to mid-July to coincide with the snowmelt runoff season. Twice daily measurements of flow in the main tributaries to the lake and its outlet will be undertaken to provide a first estimate of the water budget. Samples for major ions will be collected twice daily at each of the measurement sites while large volume synoptic water samples will be collected at strategic points. Samples will be processed at the basin and/or at Resolute but returned to NWRI for analyses.

The experience of the melt season will permit on-site staff to identify the location of and type of equipment required to more fully instrument the basin for flow stations and lake levels and groundwater inputs to the lake. With the assistance of IWD-

Yellowknife, appropriate equipment will be installed in August in preparation for a more intensive field season in 1993. The lake outflow station will become the first hydrometric station in the High Arctic undertaken as part of the expansion of the water program under the AES and will be operated jointly by NWRI and IWD-Yellowknife.

UTILIZATION OF RESULTS:

The measurement of contaminants in snow in the spring has not been verified as a true estimate of the quantity of contaminants delivered to the freshwater ecosystem as a result of snowmelt. The processes that control the timing of contaminant release to melt waters and the efficiency of the release relative to the total deposition must be quantified before any estimates of contaminant burden to surface waters can be determined. Once these contaminants have been released into the surface waters it is subsequently essential to be able to quantify the movement of these contaminants through the various compartments of the systems (e.g. lakes) so that losses and permanent and temporary sinks can be determined. It is necessary to conduct this work at a number of basins to assess the spatial variability of the abiotic processes (latitudinally as well as geomorphologically) and to continue the work for a number of years to assess annual variability due to meteorological variability.

Measurements of total contaminant transport from major river systems to the marine environment have been recognized in the arctic contaminant research strategy as being essential to estimate total contaminant burden to the Arctic Ocean. However, this fails to recognize the importance of contaminant flux within freshwater aquatic systems as well as the contaminant flux from other smaller river systems to potentially critical marine environments with restricted circulation. The study of these small basins and the quantification of the basin mass balances and the development of contaminant transport models will greatly assist in addressing this information gap.

RESOURCES:

	91/92	92/93	93/94	94/95	95/96	96/97	Total
AES	(received)		(requested)				
PYs*	0.2	0.4	0.4	0.4	0.4	0.4	
Sal	14	28	28	28	28	28	154
O&M	30	100	160	125	125	125	730
Total $K	44	128	188	153	153	153	884

* Pys have already been allocated directly to the department but are shown here in order to provide a complete record of AES support for the study.

Other (total estimated dollar value of direct and indirect contributions)

	91/92	92/93	93/94	94/95	95/96	96/97	Total
IWD/NWRI	50						
PCSP	5						
Total $K	55						

RIVERINE INPUTS OF CONTAMINANTS

PROGRAM LEADERS: D. Jeffries, D. Gregor, National Water Research Institute, Environment Canada;
R. Macdonald, Institute of Ocean Sciences, Fisheries and Oceans Canada

PROJECT TEAM: A. Redshaw, Chief, NWT Programs, Inland Waters Directorate, Yellowknife;
J. Carey, National Water Research Institute;
Northwind Consultants, Winnipeg

OBJECTIVES:

Short Term

(i) To estimate and characterize the total contaminant load delivered by major river systems to the arctic marine environment.
(ii) To characterize the source of the total contaminant burden of the selected rivers with respect to source through the use of biogeochemical markers.
(iii) To assess instream processes affecting contaminant speciation (e.g. adsorption, desorption, photodegradation, co-precipitation) as they relate to bio-availability within the aquatic system and particularly at the freshwater/marine interface.
(iv) To investigate seasonal variations of the total contaminant burden of arctic river systems and assess the controlling biogeochemical processes.

Long Term

(i) To investigate and quantify the processes and rates of contaminant transport and transformation in northern riverine systems
(ii) To refine existing temperate riverine system contaminant delivery models or develop new ones for application to arctic rivers.
(iii) To develop an understanding of the biogeochemical dynamics of contaminants in northern systems at the freshwater/marine interface.
(iv) To assess whether existing models of estuarine dynamics and transport developed for temperate systems are applicable in arctic estuarine systems.

DESCRIPTION:

A review of existing water quality data has been undertaken for a status report. As part of this work we have also undertaken a detailed classification of applicable NWT river systems based on

their regional and seasonal hydrology, suspended sediment loads, geology, geomorphology, vegetation and climate. On the basis of this information, a detailed field sampling program will be developed which will take into consideration the scientific validity and logistical feasibility of proposed methods, sampling locations, sampling frequency, logistics and interagency cooperation. The final details of this workplan will be reviewed as part of a planning and implementation workshop planned for mid-year 1992. Specific considerations at the workshop will include the rationalization of this research plan with the water quality monitoring work of DIAND and IWD as well as other relevant research and monitoring activities within the NWT.

As funding for this project was not received until January, 1992, it was not possible to implement any component of the field program. Thus this description will outline field work which will begin during the summer of 1992 as follows:

Element 1: Mackenzie River near Inuvik - Sampling will commence here during the open water season of 1992 as soon as a sampling strategy and work share agreements are established. The sampling will continue as required throughout the fall and winter and all preparations will be made for intensive investigations during the 1993 spring melt. The object here, in addition to providing quantitative analytical results, is to collect qualitative information with respect to sample representivity and sampling frequency for subsequent detailed work. This work will be coordinated with that of IOS in the delta.

Development of the sampling strategy will consider frequency of sampling under different flow regimes as well as the horizontal and vertical sampling pattern required to ensure a representative sample. This type of sampling is essential to properly calculate loadings, especially in a large complex riverine system. The decision tree that will be developed to guide future sampling will be developed on the basis of in situ measurement equipment (e.g. CTD [Conductivity, Temperature and Depth recorders]) or relatively inexpensive field measurements of pH and specific conductance. Once a sampling plan is determined for each site visit, large volume water and/or suspended sediment samples will be collected. These samples (the number for each visit will depend on the cross-sectional homogeneity or lack thereof) will be fractionated and analyzed first for the basic analytical scheme (Scheme A) which includes priority PAHs, organochlorine pesticides, and PCBs. The more intensive MS work will be conducted as the second phase of the analyses (Scheme B). This phase will include:

- the use of geochemical markers for source identification of particles and biogeochemical indicators, such as retene and perylene, for the purpose of establishing the origin of contaminants
- the investigation of isomer patterns of selected

contaminants for evaluating transformations
- the use of the ratio of methylated pyrene to pyrene as an indicator of biochemical changes
- alkyl homolog distributions (slope of the PAH alkyl homolog distribution curve can give information on the formation temperature and thus source {i.e. natural vs internal combustion engines vs high temperature furnaces})
- hydrocarbon and alkane distributions (useful to discriminate between natural sources, crude oils and anthropogenic sources of hydrocarbons).

Element 2: Intensive Investigation of another river system - Loadings to the Arctic Ocean must be assessed close to the river mouth. The size the Mackenzie River basin will limit some of the interpretation that might be possible on smaller systems and therefore, it is planned to commence more intensive work on another major tributary to the Arctic Ocean. In FY 92/93, this will be limited to one intensive sampling period at one site. The sampling and analyses will be comparable to that proposed for the Mackenzie River at Inuvik site. The site selection and detailed sampling strategy will be developed at the workshop planned for the summer of 1992.

Element 3: Reconnaissance sampling of major northward flowing rivers - Although the Mackenzie River is the largest Canadian river tributary to the Arctic Ocean, there are other significant river systems which are draining basins entirely different from that of the Mackenzie. In particular, river systems such as the Back and Hayes drain large areas of tundra which are likely to deliver contaminants from snow melt differently than large portions of the Mackenzie valley which is treed and mountainous. Second, the eastern arctic may be subject to different loading rates and contaminant mixtures than the Mackenzie valley (contaminant deposition patterns and mixtures will be assessed through the spatial snow surveys).

To initially compare these river systems, we propose an extensive reconnaissance survey of major tributaries near the mouths. This work will be coordinated with IWD Water Resources Branch in an effort to minimize air charter costs. At each site visited, suspended sediment and/or large volume water samples will be collected. All of these samples will be analyzed following Schemes A and B, outlined above. These data, along with the contaminant deposition in snowpacks and the regional and seasonal hydrology information will be used in determining future sampling scenarios for river systems outside of the Mackenzie basin. Due to the high cost and intensive nature of this work, it will be undertaken over the course of two field seasons.

UTILIZATION OF RESULTS:

The focus of the AES is the evaluation of contaminant transport to the marine ecosystem, uptake in the bio-system, and possible effect on top predators (i.e. humans). Northward flowing rivers, which drain 10^7 km^2 of northern Asia, northern Europe and North America, are thought to be major conduits to the Arctic Ocean of contaminants originating from point sources and/or atmospheric deposition to the terrestrial ecosystem. Most of the major rivers are found within Europe and Asia. The Mackenzie River is the only major north-flowing river in North America. Freshwater inflows contribute to the stable, less dense, more productive surface layer and adjacent to river mouths, introduce turbid water and establish horizontal density gradients which drive ocean currents. The processes controlling the timing and rate as well as the forms of the contaminants delivered to the marine environment by the river systems, likely differ from those in temperate climates. Similarly, the impact on the coastal, productive receiving waters must also be assessed to fully appreciate the importance of the riverine delivery of contaminants.

RESOURCES:

	91/92	92/93	93/94	94/95	95/96	96/97	Total
AES	(received)		(requested)				
PYs							
Sal							
O&M	65	120	220	220	135	130	990
Total $K	65	120	220	220	135	130	990

Other (total estimated dollar value of direct and indirect contributions)

	91/92	92/93	93/94	94/95	95/96	96/97	Total
NWRI	10						
Total $K	10						

Note: This project had not been funded prior to January, 1992. As a result of this late funding and the delays resulting from the government wide freeze on activities, only the preparatory and planning work, undertaken under contract, could be completed during FY 1991/92. There was insufficient time to implement a sampling program for the 1992 spring freshet. Resources over and above the contract to Northwind were used for the purpose of purchasing necessary field equipment to support the field program in FY 1992/93.

SOURCES, PATHWAYS AND SINKS OF PESTICIDES IN THE YUKON RIVER AND LAKE LABERGE

PROGRAM LEADERS: D. J. Gregor, National Water Research Institute, Environment Canada;
D. Muir, Fisheries and Oceans Canada, Freshwater Institute;
J. Eamer, Environmental Protection, Environment Canada

PROJECT TEAM: P. Wilkinson, Freshwater Institute, Winnipeg;
D. Davidge, Environmental Protection, Whitehorse;
M. Alaee, C. Tiexira, R. Rowsell, National Water Research Institute, Burlington

OBJECTIVES:

Short Term

i) To undertake bottom sediment sampling from the deep water zone of Lake Laberge for the purpose of documenting the trend of anthropogenic contaminants.
ii) To undertake site specific water column characterization of Lake Laberge and large volume water sampling for analyses of trace organic contaminants, especially toxaphene, DDT and PCBs, in Lake Laberge and along the Yukon River between Marsh Lake and Lake Laberge during low flow conditions for the purpose of identifying potential contaminant sources to the system and contaminant fate within the lake system.

Long Term

i) To develop additional information on the state of trace organic contaminants in the Yukon River and Lake Laberge and to assess the groundwater inputs to the Yukon River as potential sources.
ii) To use the information gained from this intensive survey to develop a more detailed plan of investigation of contaminant sources, pathways, sinks and trends in the Yukon R./Lake Laberge system and to assess remedial actions.
iii) To develop recommendations for long term monitoring or additional special studies of trace organic contaminants in the Yukon River system.

DESCRIPTION:

Lake Sediments

This work was undertaken by Freshwater Institute, DFO, Winnipeg and has accordingly been reported on separately. A total of $10K was transferred from NWRI to FWI to support this work in FY 1991/92.

Water Samples

Detailed investigations of the water chemistry were to be conducted during low flow conditions in late winter in order to sample during the period when flow is dominated by groundwater inputs. This is based on the premise that the sources of contaminants to the river system, in particular DDT, toxaphene and PCBs, are "dump" sites. If this is the case, then concentrations should be at a maximum during low flows and possible source areas will be most easily identified based on the variable chemistry of site specific samples. Unfortunately, due to the unseasonably early spring experienced in the Yukon in 1992, a great deal of snowmelt had occurred by the time sampling was undertaken in late March. This not only made it difficult to sample some sites due to thin ice and poor travelling conditions (i.e. not sufficient snow and too warm for snow mobiles but too difficult for ATVs) but reduced the effectiveness of sampling for the purpose of locating groundwater inflows adjacent to dump sites. Thus additional emphasis was placed on atmospheric sources of pesticides, especially toxaphene.

Water and snow samples for trace organic contaminants were collected in large volumes to provide sufficient sample for quantification and MS confirmation (as appropriate) of organochlorine pesticides and PCBs. The samples will also be analyzed for PAHs in order to investigate possible sources of petroleum contamination to the river system. The sampling locations are listed in Table 1.

The water columns of Laberge, Atlin and Kusawa Lakes were profiled near the points of maximum depth to determine the structure (thermal and chemical) of the lake. The instantaneous nature of this information was used to determine sampling depths for the large volume water samples.

All sites were sampled for major ions and trace metals at the same time as the large volume water samples were collected. The large volume samples were immediately extracted at Whitehorse using continuous liquid/liquid extraction. Extracts were then returned to Burlington for concentration, clean-up and analyses. Analyses will be completed in 1992/93.
Water data will be synthesized and evaluated with recommendations and conclusions, as feasible, for specific site investigation and clean-up. Water and sediment data will be used to identify future monitoring and research needs.

UTILIZATION OF RESULTS:

Sediment samples were previously collected at the 20 m depth contour of Lake Laberge at the inlet and the outlet. These samples were analyzed for organochlorines with none being detected. This is likely a result of the fact that these shallow water samples represent clean material delivered to the lake from the highly turbid Takhini River. Contaminants delivered to the lake in soluble

form or adsorbed to particulate matter from the much less turbid Yukon River are more likely to be found in profundal sediments at the centre of the lake.

Small volume water samples have been analyzed for the contaminants of interest but with no detectable levels. More intensive large volume samples are required to determine the concentration of contaminants in the lake water and to investigate possible sources of contaminants to the river system from dump sites and other areas. These data are also necessary to provide a yardstick against which to investigate the effect of remediation as well as to provide a more comprehensive data base for the effective design of further research and monitoring activities within the basin.

RESOURCES:

AES	91/92 (received)	92/93	93/94	94/95	95/96 (requested)	96/97	Total
PYs							
Sal							
O&M (NWRI)	18						
O&M (FWI)	10						
O&M (EP)	16						
Total $K	44	26					77

Other (total estimated dollar value of direct and indirect contributions)

	91/92	92/93	93/94	94/95	95/96	96/97	Total
IWD/NWRI	25						
EP/C&P	10						
Total $K	35						

Table 1: Sampling in the Yukon River Basin, March, 1992 - Water and Snow

Water

1. Lake Laberge - point of maximum depth (142 m) -surface
2. Lake Laberge - point of maximum depth (142 m) -137 m
3. Kusawa Lake - point of maximum depth
4. Bennett Lake at Carcross
5. Atlin Lake - near point of maximum depth - surface
6. Atlin Lake - near point of maximum depth - 225 m
7. Atlin Lake at outlet
8. Little Atlin Lake
9. Tagish Lake at outlet to Yukon River
10. Yukon River below Marsh Lake
11. Yukon River at Schwatka Lake
12. McIntyre Cr. near confluence with Yukon River
13. Small ponds at base of Range Road dump
14. Yukon River at base of Range Road dump
15. Yukon River above confluence with Takhini River
16. Takhini River above confluence with Yukon River

Snow

1. White Pass (59° 42′ 47.94" N, 135° 05′ 56.35"W) (760 masl)

DEPOSITIONAL TRENDS: LAKE SEDIMENTS

PROGRAM LEADER: W.L. Lockhart, Fisheries and Oceans Canada

PROJECT TEAM: P. Wilkinson, B. Billeck, R. Danell, D. Muir, R. Hunt, R. Wagemann, B. Hauser, E. Slavacek

OBJECTIVES:

Short Term: To obtain sediment core samples from a grid of arctic headwater lakes in sufficient quantities to permit determinations of layer ages using radionuclide concentrations and down-core profiles of contaminants, polycyclic aromatic hydrocarbons, organochlorines, and metals. One arctic location is to be done per year.

Long Term: To derive the LRTAP input rates required in order to produce the core profiles found for each contaminant, set current rates of supply in the context of those which have been taking place over the last century and longer. The history of contaminant supplies determined from the sediment records will be tested to see whether they predict contaminant levels and contaminant-induced responses in fish from the same lakes. Where possible, contributions of contaminants from within the drainage basin will be determined.

DESCRIPTION:

This project is designed to reconstruct the histories of contaminant inputs to northern lakes, as recorded in lake sediments. This approach has been used successfully in lakes throughout the world (Hites *et al.*, 1977; Heit *et al.*, 1981; Gschwend and Hites, 1981; Czuczwa and Hites, 1987; Johnson, 1987), but has not been used extensively in the Canadian Arctic. The contaminants of interest are the organochlorines which have no natural sources, and the heavy metals and polycyclic aromatic hydrocarbons which have both natural and anthropogenic sources.

During 1991/92, two field expeditions were undertaken. In May four DFO personnel visited Buchanan Lake, Axel Heiberg Island, with assistance in the form of aircraft time and ground equipment from the Polar Continental Shelf Program. Buchanan Lake was reached by helicopter from the Atmospheric Environment Service station at Eureka. Coring at Buchanan Lake completed the planned north/south transect as envisaged originally. To date, the sites from which we have obtained cores are:

Lake	Latitude	Date
ELA Lake 382	50	March, 1988
ELA Lake 375	50	March, 1989
Saqvaqjuac, Hawk Lake	64	May, 1988
Saqvaqjuac, Far Lake	64	May, 1988
Cornwallis I. Sophia Lake	75	June, 1989
Cornwallis I. Amituk Lake	75	June, 1989
Ellesmere I. Lake Hazen	82	May, 1990
Axel Heiberg I. Buchanan Lake	79	May, 1991
Yukon Territory, Kusawa Lake	60	March, 1992

With completion of coring at Buchanan Lake in 1991, emphasis has shifted from the north/south transect to a grid covering the Canadian Arctic. The first site in expanding to a grid network was Kusawa Lake in the Yukon Territory, chosen as a convenient "control" for similar studies at Lake Laberge.

During 1990 the emphasis has been on completing the analyses of the cores taken at Lake Hazen in 1990, and on beginning those from Buchanan Lake. The analytes of interest have been lead-210 as the principal dating tool, and suites of organochlorines, heavy metals and polycyclic aromatic hydrocarbons. Ability to handle these samples has been improved with the addition of a new GC/MSD system so that now one system is largely dedicated to organochlorines and the new one to organochlorines. Several bulk sediment parameters are also measured, such as loss on ignition as a surrogate for organic carbon.

RESULTS:

a) PAHs

Analyses for PAHs has improved over the duration of the program. Initially analytes were the sixteen "priority pollutants" from a list derived by the U.S. Environmental Protection Agency (Keith and Telliard, 1979), plus perylene. Experience has allowed the list to expand so that more recent samples can be analyzed for the original group of seventeen plus some sixty additional compounds, mostly alkylated derivatives of the original group.

Sediment profiles are largely completed for the sites sampled prior to Buchanan Lake. With PAHs, there is a consistent pattern shown by the Experimental Lakes Area (ELA) in northern Ontario, Saqvaqjuac and Cornwallis Island, with concentrations in top slices of sediment elevated above historical background concentrations (Figure 1). At ELA and Saqvaqjuac there is a sub-surface maximum, implying that current inputs, while above historical inputs, are below those of the recent past. Similar patterns from lakes in the northeastern U.S.A. have been interpreted as reflecting the use of coal as a home heating fuel until the mid years of this century, followed by a switch to cleaner fuels. The fact that this pattern

is much more pronounced at both ELA lakes than at Saqvaqjuac suggests that ELA may be closer to the source region. On Cornwallis Island the same pattern may be present, but the levels are so low that it is difficult to reach any conclusion except that the top slices are about double the historical background. Lake Hazen had a completely different PAH profile, with a consistent increase in concentration throughout the core. The composition of PAHs at Lake Hazen suggested that local deposits of coal and amber might be the principal source of PAHs in the sediments, and not atmospheric deposition as at the other sites.

Preliminary results from Buchanan Lake indicate a similar problem there; PAH levels are higher than in any of the other lakes sampled to date, with several slices exceeding 2000 ng/g. Furthermore, there was no clear trend on changing concentrations with core depth.

b) Organochlorines

A large number of organochlorine compounds have been identified in core slices. Table 1 lists a sample of the residues found for PCBs and DDT. These data suggest a south-to-north gradient in DDT concentrations in the most recent sediments, with higher concentrations in more southern locations (Figure 2). For PCBs, however, the concentrations are similar over the range from latitude 50 to 79, with Sophia Lake having a low concentration. Amituk lake nearby, however, had a PCB concentration in the range of the other lakes. Lake Hazen, the most northern location sampled, had the lowest PCB value recorded for a surface sediment layer.

Table 1. DDT and PCBs in top slice of lake sediments.

Lake site	Latitude	DDT in top slice ($ng\ g^{-1}$ dry wt)	PCBs in top slice ($ng\ g^{-1}$ dry wt)
ELA Lake 375	50	6.9	12.3
ELA Lake 382	50	11.0	13.6
Hawk Lake	64	5.2	33.7
Far Lake	64	1.6	13.2
Sophia Lake	75	0.3	3.5
Amituk Lake	75	1.7	13.2
Buchanan Lake	79	0.7	10.8
Hazen Lake	82	0.1	2.5

c) Heavy metals

The results for heavy metals are illustrated with mercury. Table 2 lists the average mercury concentrations found in the top five slices of sediment from each lake. These concentrations may also be compared with the mean mercury found in lake trout or arctic charr

from the same lakes. Again, as seen with DDT above, there was an apparent gradient in surface sediment concentrations from south to north, with higher concentrations found in the south. The concentrations in the surface sediments did not predict well the mean concentrations in the fish from the same lakes.

Table 2. Mean mercury concentrations in the top five slices of sediment from several lakes, and the mercury levels in the fish from the same lakes (not corrected for fish size or age).

Lake	Mercury in top 5 slices (ng g^{-1} dry wt)	Mean mercury in fish muscle (ng g^{-1} wet wt)
Lake375	162.6	0.379
Hawk	110.2	0.238
Far	87.4	0.340
Amituk	45.6	0.767
SophiaA	16.6	0.143
SophiaB	12.8	0.143
Hazen	ca. 10.0	0.181

Cores from ELA, Saqvaqjuac and Cornwallis Island all showed mercury increasing in slices nearer the surface relative to slices near the bottom (Figure 3). This excess of mercury in the top slices of sediment over mercury in the bottom slices indicates increases in inputs of mercury in recent time. Converting the concentrations to estimates of net flux, ignoring within-lake sediment focusing, produced the estimates listed in Table 3, which suggest that current fluxes exceed historic ones by factors from about two to about seven (Lockhart, 1992). This increase is consistent with a recent report of increasing mercury in the air of the northern hemisphere (Slemr and Langer, 1992).

Table 3. Current and historic fluxes of mercury to lake sediments, estimated from concentrations in top and bottom core slices respectively.

Lake site	Recent flux (ug m^{-2} yr^{-1})	Historic flux (ug m_2 yr^{-1})
ELA Lake 375	21.3	11.8
Hawk Lake, N.W.T.	4.48	0.64
Far Lake, N.W.T.	6.31	3.00
Sophia Lake, N.W.T. (A)	3.57	<1.23
Sophia Lake, N.W.T. (B)	3.72	<1.77
Amituk Lake, N.W.T.	17.2	4.23

One long-term objective of this program is to test whether there is some relationship between mercury in the sediments and mercury in the fish. The published literature is somewhat ambiguous on this, with such associations sometimes apparent, but not always. We have sufficient analyses from the fish and sediments now to begin testing for such associations. For example, data on mercury in the fish (Table 2) can be combined with the flux measurements (Table 3) and tested for associations. There was no relationship between the concentration of mercury in the fish and that in the sediment; however, there was some relationship between mercury in the fish and the flux to the top layer of sediment ($r=0.774$, $p=0.055$) with higher fluxes associated with higher concentrations in the fish. This observation is consistent with data on lakes in Ontario (Johnson, 1987). Age determinations have not been completed on all the fish, and when these are available, the testing for associations will be more rigorous since some contaminants are often related to body size and age measures.

Fish mercury levels were unusually high in Amituk Lake. The population in this lake is landlocked, and the fish are thought to have a slow growth rate. (Ages of these fish have not been determined yet.) The lake is too far from the community of Resolute Bay to be a regular source of human food. Nonetheless, other small lakes with landlocked populations should be tested to determine whether similar high levels are present.

d) Carbon

Samples from the lakes listed above (as well as Hazen basin coal and brown snow from Saqvaqjuac) have been made available to Dr. J. Smol and N. Doubleday at Queen's University for the analysis of black carbon particles (morphology, distribution, abundance). In addition, they will collect samples at Alert this summer and will receive materials from the Atmospheric Environment Service air sampling at Alert. Analysis of the core samples to date has been deferred pending the arrival of a class-100 clean sphere. This equipment has now arrived and processing of the core samples will begin as soon as installation is completed in April. Preliminary examination of Hawk Lake sediments and of the brown snow sample indicated the presence of black carbon particles. In the case of the brown snow, the particulate material appears to include coal particles, however, definitive identification is still pending.

RESOURCES: (received in 1991/92, 1992/93 and planned under Green Plan AES)

	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
O&M ($K)	130	88	140	110	120	60

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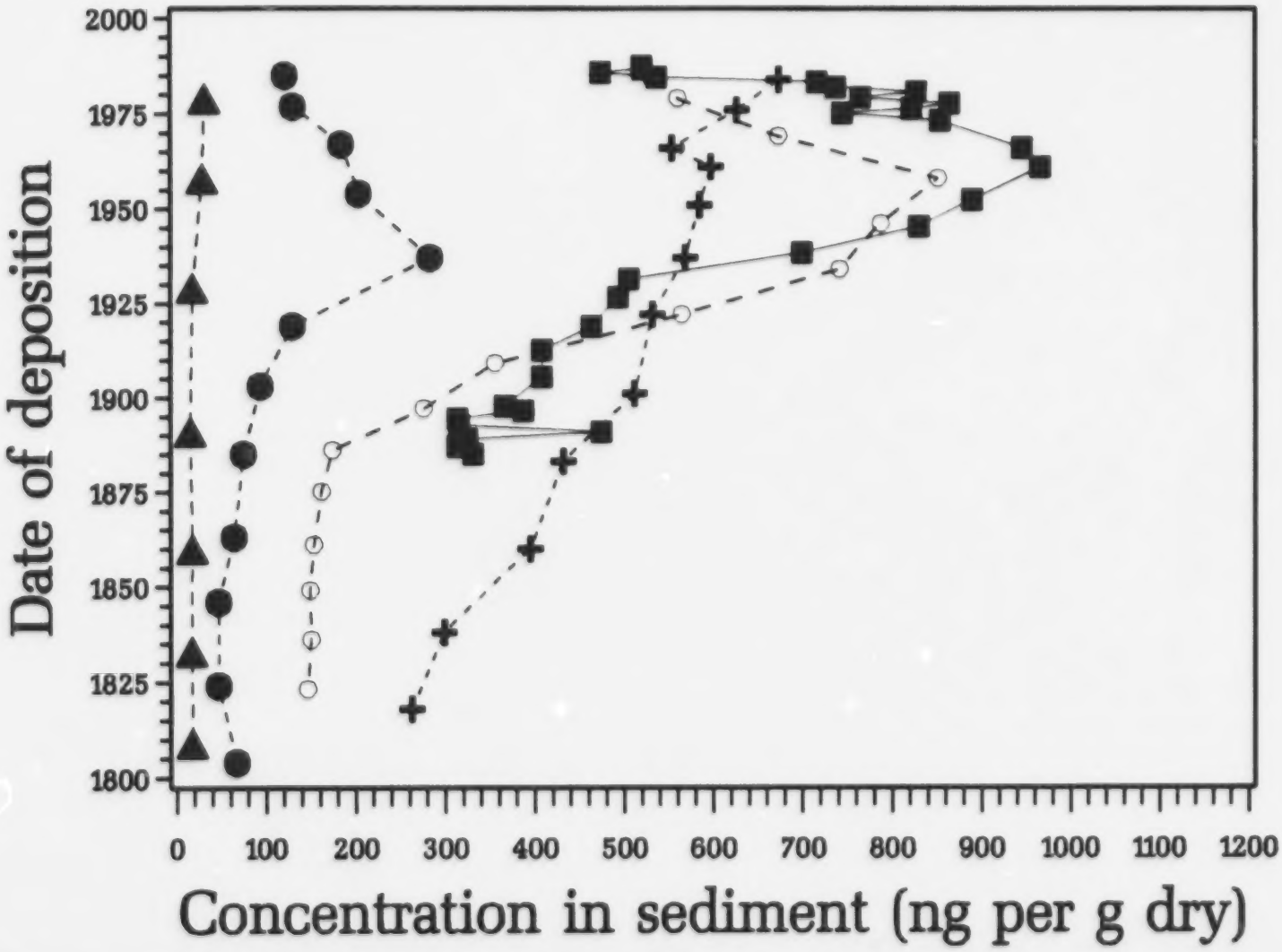
Fig. 1. Sum of sediment core PAH minus perylene and retene
Sophia, Hawk, Hazen Lakes, NWT, and Lakes 382 and 375, ELA

Sophia ▲ Hawk ● L382 ■ L375 ○ Hazen +



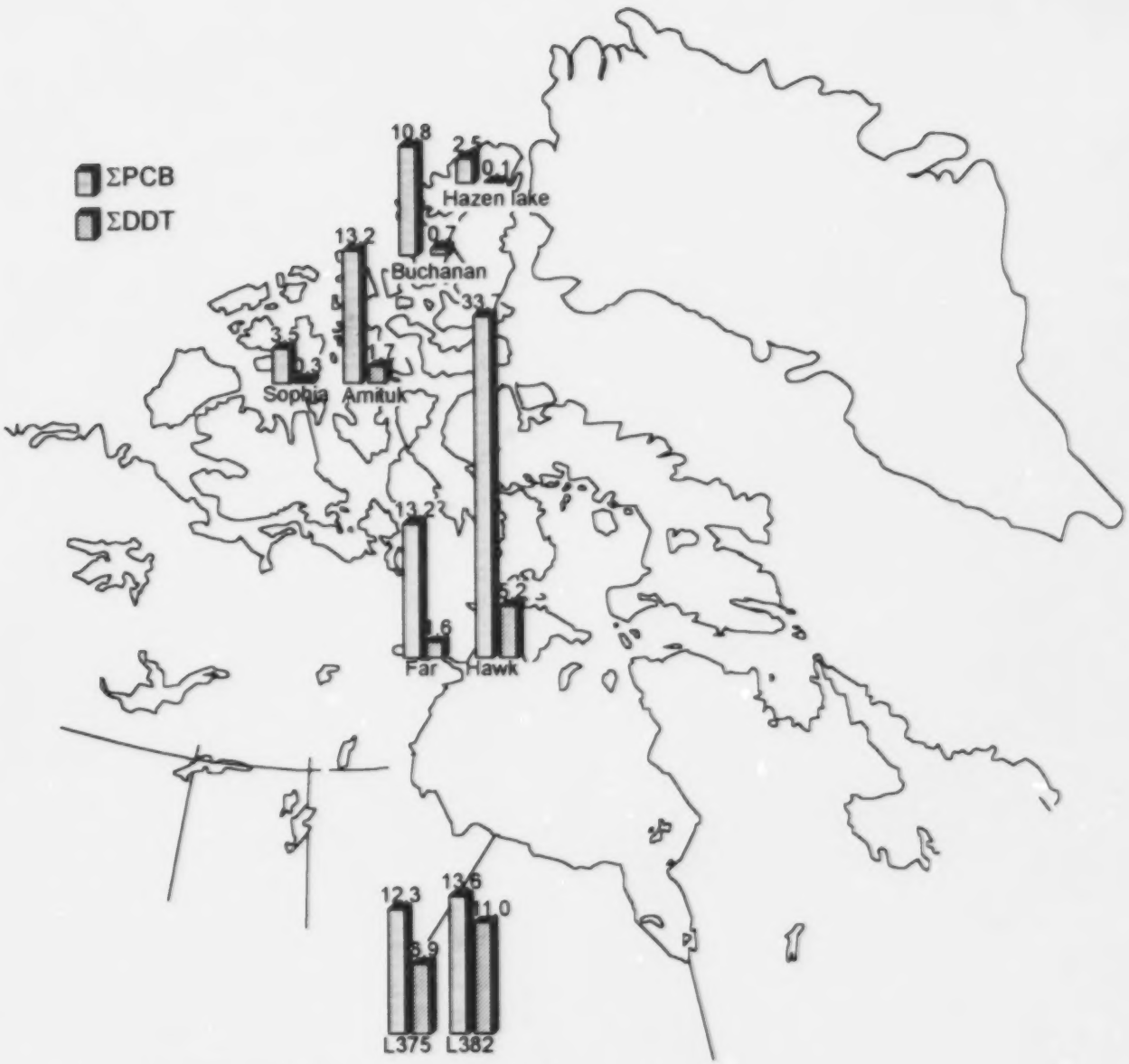
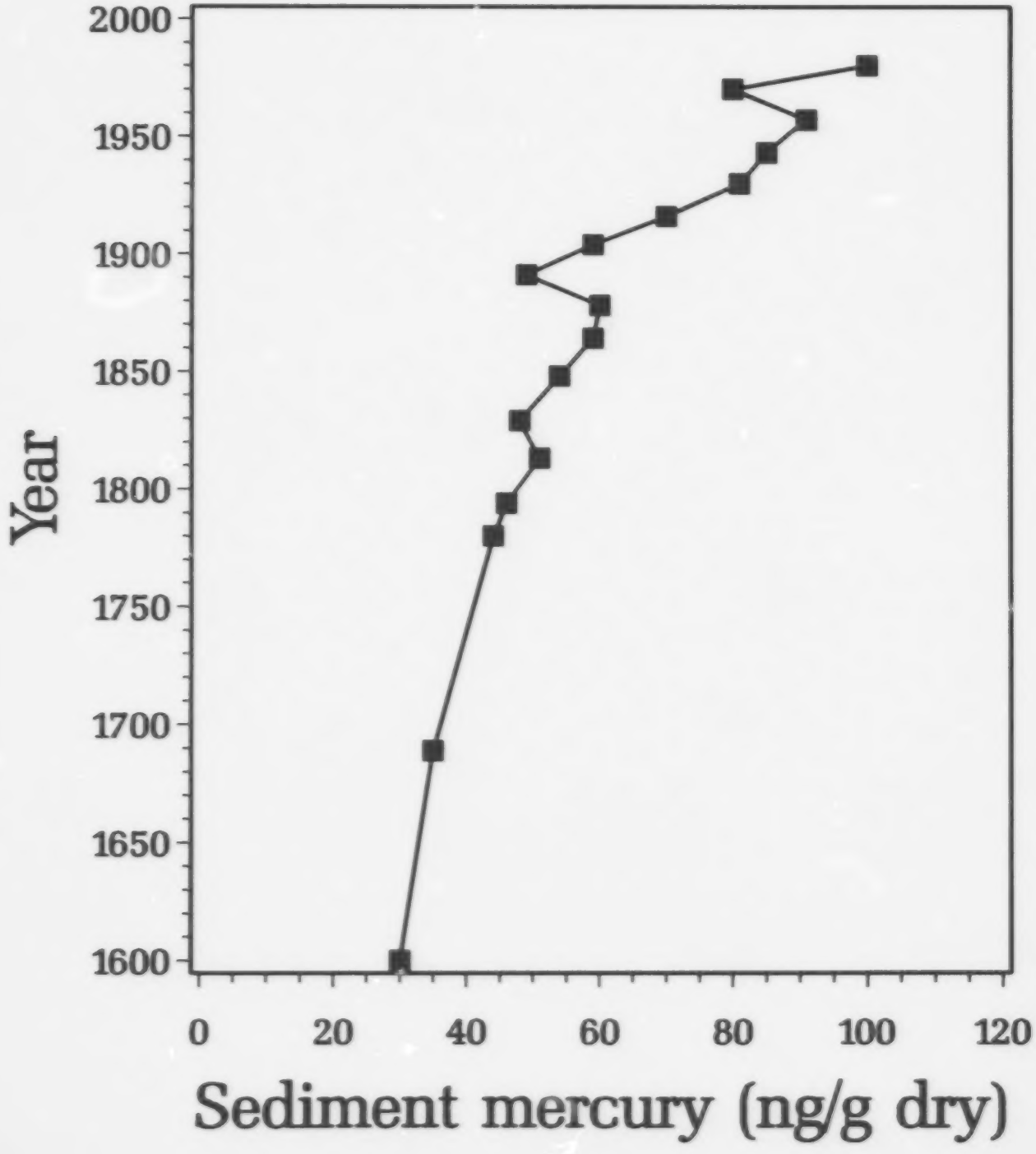


Fig. 2. ΣPCB and ΣDDT in lake sediments (0-1 cm) from the Canadian Arctic (ng/g dry wt)

Fig. 3. Mercury in sediment slices, Far Lake, N.W.T. 1988, Core A, total mercury (dates tentative) DFO Winnipeg, unpublished



LABORATORY INVESTIGATIONS OF PHYSICAL AND CHEMICAL INTERACTIONS OF CONTAMINANTS IN AIR, WATER (SNOW) AND SOILS

PROGRAM LEADERS: D. J. Gregor, National Water Research Institute, Environment Canada
L. Barrie, Atmospheric Environment Service, Environment Canada

PROJECT TEAM: E. Lee Ruff, York University, Toronto
M. Alaee, National Water Research Institute
H.H. Angus & Associates Ltd., Consulting Engineers

OBJECTIVES:

Short Term

i) To design, construct and instrument an ultra clean arctic simulation chamber (light, wind speed, humidity and temperature controlled) in which to conduct a range of experiments.
ii) To investigate chemical transformations and photo-degradation of selected organochlorine compounds and PAHs in the atmosphere.
iii) To investigate air/water (snow and ice) exchange under a variety of environmental conditions (e.g. temperature, humidity, snow physical properties and morphogenesis, wind, surface roughness).
iv) To investigate in a controlled setting the timing of the release of a spectrum of contaminants of different solubilities and vapour pressures during snowmelt under simulated polar conditions.
v) To investigate the photochemical changes that occur in snowpacks for a variety of organic contaminants as a result of polar sunrise.

Long Term

i) To develop the necessary controlled chamber data to help design and parameterize field experiments to understand and predict processes operative in controlling the exchange between the air and surface environments of polar regions.
ii) To utilize the understanding and quantification of the various processes, transformations and exchanges developed here and physical/chemical properties of a variety of compounds being developed elsewhere to assist in the refinement of contaminant transport and fate models.

DESCRIPTION:

In FY 1991/92, two activities were undertaken to initiate this project following receipt of funding in January, 1992. These were:

i) A contract to design and provide detailed specifications for the cold room simulation chamber from which the tender documents will be prepared if funding is obtained to support this work. H.H. Angus & Associates Ltd. were the consulting engineers on this project and have provided a Construction Document as well as detailed specifications and blue prints of all components (physical layout, electrical, refrigeration, mechanical, etc.) of the simulation chamber. H.H. Angus was selected in part on the basis of their experience in constructing similar climate controlled chambers, including a low temperature facility, for the Ontario Forest Research Centre in Sault Ste. Marie. It was intended to proceed to construction phase in early FY 1992/93 so that experiments could be initiated in late 1992; however, this project has not been funded by the Arctic Environmental Strategy during FY 1992/93.

ii) A contract to York University to conduct a comprehensive literature review on the physical and chemical properties pertaining to environmental transport and degradation of individual isomers of HCHs and chlordane. The report will also identify knowledge gaps for which specific research is required with respect to the environmental degradation of these compounds in the atmosphere. This information is essential for the atmospheric transport model being developed by Atmospheric Environment Service of DOE. Due to the late arrival of funding from the AES, this work commenced late in FY 1991/92 and the interim report on the first phase of the work will not be completed until mid June, 1992. Unfortunately, the AES has also not decided to continue funding this work and this phase will be completed utilizing A-base resources of NWRI and Atmospheric Environment Services.

UTILIZATION OF RESULTS:

While pesticide use and emissions have been identified as a major information gap, so too is the question of the physical and chemical interactions and transformations of trace organic contaminants and PAHs within and between air, water (including snow) and soils. For example, we know that pesticides like lindane degrade to α-HCH but we have no understanding of the factors that control the rate of this degradation. Other compounds degrade but we know little about their degradation products. Similarly, we have limited understanding of the interaction of gaseous compounds with atmospheric aerosols. This information is essential to the development of the atmospheric transport and deposition model.

In addition, although concentrations of trace organic contaminants have been quantified in the atmosphere and waters of the Arctic, the research to date has generally not been directed at understanding scavenging processes from the atmosphere, the effect of temperature, humidity, light etc. on the snow/air exchanges and chemical degradation of the compounds in the snowpack. Field

experiments have been conducted to date to investigate some of these phenomena but with limited success due to the inability to control the numerous variables in the field. Thus further investigation can be accelerated and enhanced through the use of a specially designed cold room facility for laboratory investigations and field scale experimental chambers. We know even less regarding PAHs.

There is no other facility within Canada that can be used to undertake these simulations and thus the AES will be contributing to the establishment of a centre of expertise on trace contaminants in polar environments which is critical for Canada to have if it is to effectively manage its northern natural resources.

RESOURCES:

	91/92	92/93	93/94	94/95	95/96	96/97	Total
AES	(received)		(requested)				
PYs*	.1		.4	.4	.4	.4	
Sal	7		28	28	28	28	147
O&M	50		80	50	20	20	370
Total $K	57	0	108	78	48	48	517

* Pys and salary dollars have already been allocated directly to the department but have been shown here to provide a complete record of AES support for the study.

Other (total estimated dollar value of direct and indirect contributions)

	91/92	92/93	93/94	94/95	95/96	96/97	Total
NWRI	24						
Great Lakes Supp. Fund	10						
Total $K	34						

GLACIAL SNOW/ICE CORES AND PEAT CORES

PROGRAM LEADER: D. J. Gregor, National Water Research Institute, Environment Canada

PROJECT TEAM: R. M. Koerner, Energy Mines and Resources, Ottawa
S. Edlund, Energy Mines and Resources, Ottawa
C. Spencer (contractor)
B. Warner, University of Waterloo

OBJECTIVES:

Short Term

i) To quantify annual deposition and historical residue trends of trace organic contaminants in arctic glaciers including differentiating between annual variability of deposition as a result of variable atmospheric conditions.
ii) To determine the major processes controlling the fate of these contaminants in glaciers including re-volatilization to the atmosphere, transfer between annual layers by gas transfer and melt water and photochemical degradation within the snow layers.
iii) To identify compounds not routinely considered in the organochlorine pesticide/PCB suite, including toxaphene, and to measure the trend of selected compounds of general concern.
iv) To identify active peat bogs within the Arctic and to identify appropriate methods to quantify trends of contaminant deposition.
v) To compare findings from Canadian research with comparable research from glaciers and peat bogs within Russia and other circumpolar countries.

Long Term

i) To quantify the current annual and historical trends of trace organic contaminant deposition in glaciers of the Canadian Arctic and to compare these with other historical information regarding trends in the Arctic and world-wide production and use.
ii) To quantify the current annual and historical trends of trace organic contaminant deposition in peat bogs of the Canadian Arctic and to compare these with other historical information regarding trends in the Arctic and world-wide production and use.

DESCRIPTION:

Glacial Snow/Ice Cores

The initial work on Agassiz Ice Cap to investigate trends of

contaminants stored in the glacial snow and ice was undertaken in 1986 and 1987. This work has been published in Gregor, 1990; Barrie *et al.*, 1992; Gregor, 1991a; Gregor, 1991b and Gregor *et al.*, (in press). Subsequent to this intensive study we have been maintaining an annual watch on deposition to the ice cap so that we can continue the profile. These data are presently under review as part of the preparation for the major new sampling project planned for the spring of 1993. This new effort will extend the parameter list to match current research activities in the north, will ensure consistent sampling throughout the entire profile and permit temporal profiling from approximately 1940 to the present thereby greatly extending the current record. This work had also been delayed to allow time to undertake laboratory experiments with respect to air/snow exchange phenomena in order to better interpret the trend profiles for the more volatile compounds (e.g. HCHs). However, this research is no longer being funded by the Arctic Environmental Strategy. Thus emphasis will be on the less volatile compounds in future excavations. Work on the Ice Cap in 1992 will be limited to:

-replicate bulk snow sampling for the last two years to confirm previous findings regarding the loss of the more highly volatile compounds and the stability of the less volatile compounds including the higher chlorinated PCBs and toxaphene; and

-replicate sampling of fresh and one year old snow to confirm methods for ^{210}Pb and for selected compounds that have not previously been considered in the ice cap studies, specifically PAHs and toxaphene

In addition, opportunities will be pursued to identify contacts and exchange field and analytical techniques for similar projects in other circumpolar countries especially the USA, Russia and Denmark/Greenland.

Peat Cores

The peat core work has been limited to literature reviews and the general development of methods in FY 1991/92. This work was undertaken by Ms. C. Spencer under contract to NWRI. A final report was received at the end of March, 1992. This report is under review at the present time and the final accepted report will be forwarded to DIAND in the near future. The review and finalization of this report is however presently not a high priority as this work is not to be funded by the Arctic Environmental Strategy in the future. In summary, this report provides a review of all published and known work on peat bogs in Canada north of 60°N, including information with respect to accumulation rates, type of vegetation, status with respect to active or relict, etc. There has been little work in the north other than surface peat studies for heavy metals and there has been no work on trace organic contaminants. We now have a good understanding of the complexity of working in the very slow growing bogs that are found in the Arctic and are convinced that the only type of peat that will have sufficient annual accumulation to be of

use will be small ombrotrophic *Sphagnum fuscum* or *Sphagnum magellanicum* bogs. We also know that these types of bogs occur throughout most of the NWT except for the arctic islands but accumulation rates are low, thus probably restricting sites to near or south of the tree line. This work would be worthwhile to pursue in the future due to the growing concern over toxaphene in the Arctic. As noted by Rapaport and Eisenreich (1986) the fact that the top portion of peat bogs (acrotelm) are aerobic, minimizes the degradation of toxaphene. As well, it is feasible to identify annual layers in peat monoliths and thus the temporal resolution is greatly enhanced over that for lake sediments.

UTILIZATION OF RESULTS:

To date there is inadequate information regarding current contaminant deposition in arctic ecosystems as well as details with respect to the trends of many of these contaminants. Glaciers have been utilized to measure changes in global tropospheric chemistry over long time periods, specifically with respect to climate change (e.g. CO_2), inorganic pollutants resulting from global industrialization, and the effect of naturally occurring large scale phenomenon (e.g. volcanoes). However, a great deal more work is required to determine the historical trend of pollutants contained in circumpolar glaciers. In part this is due to the semi-volatile nature of a large number of the contaminants of interest with the result that the glaciers, as well as all known accumulation medium (e.g. lake sediments), are apparently an inefficient trap for many of these compounds. Also, the effect of annual variability in deposition as a result of variable meteorologic conditions has not been studied adequately to permit assessment. This is not a concern when dealing with very long term trends of several thousand years but could be of great importance in the medium term such as the last 50 years.

The investigation of the temporal record of trace organic contaminants in glacial snow and ice has been ongoing since 1986 but at a very slow rate due to limited resources. Through direct collaboration with Dr. Koerner, it will be feasible to link the present work on organic contaminants to his extensive research on glacial mass balances, climate change and inorganic glacial and snow chemistry. Direct collaboration with Dr. Nriagu will also permit us to investigate metal trends in the ice cap.

Ombrotrophic peat bogs in temperate regions, which have an internal drainage system and therefore receive moisture and thus contaminants only from the atmosphere, have been investigated and have shown a trend of contaminant deposition which compares favourably with the reduction in the use of contaminants within the regional air-shed (e.g. PAHs reduced as a result of the conversion from coal to oil as a home heating fuel). This line of research has not been explored in the North and warrants investigation as a source of depositional trend data.

Both lines of research readily lend themselves to comparison with other circumpolar sites. As we try to define pathways to the Arctic it is important that comparable information be obtained from other circumpolar sites. Efforts will be made to contact researchers in other countries (e.g. Greenland, U.S. and Russia) to influence research in those countries in order to provide comparable data. Methods will be compared or standardized and quality assurance protocols will be established to compare analytical data.

RESOURCES:

	91/92	92/93	93/94	94/95	95/96	96/97	Total
AES	(received)		(requested)				
PYs*		.2	.2	.2	.2	.2	
Sal		14	14	14	14	14	70
O&M	60	34	180	50	180	50	683
Total $K	60	48	194	64	194	64	753

* PYs and salary dollars have already been allocated directly to the department but have been shown here to provide a complete record of AES support for the study.

Other (total estimated dollar value of direct and indirect contributions)

	91/92	92/93	93/94	94/95	95/96	96/97	Total
NWRI	25						
PCSP	5						
Total $K	30						

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ECOSYSTEM CONTAMINANT UPTAKE AND HEALTH EFFECTS

ECOSYSTEM CONTAMINANT UPTAKE AND HEALTH EFFECTS OVERVIEW

Recent Findings

1) In a circumpolar survey of organochlorine contaminants in polar bears, the major residues found in all areas were PCBs and chlordane-related compounds. Asia appears to be a more important source of HCH than North America, whereas North America is a significantly more important source of DDT than other areas. The significantly higher levels of PCBs in north Atlantic regions than Hudson and Baffin Bays indicates that European sources are major contributors to these regions.

2) In a circumpolar survey of beluga whales, the major organochlorine contaminants in all blubber samples were PCBs, toxaphene (PCCs), DDT and chlordane.

The highest levels of PCBs and other contaminants were found in juvenile animals, and in males of all ages, and the lowest in older females.

Mean concentrations of PCB and DDT in males from Nuussuaq (5.6 and 4.4 μg/g, respectively) were significantly higher than in males from Jones Sound and East Hudson Bay.

3) Levels of PCB 169 in male beluga blubber from the Beaufort Sea (588 ng/kg) are 6-times greater than previously reported levels. This may be due to the rapid mobilization of this compound compared to lower molecular weight PCBs.

4) DNA oxidation has been identified as an important biomarker for cancer mutagenesis. Two indicators of oxidative damage, 8-hydroxy adenine and 4,6-diamino-5-formamidopyrimidine, were detected in beluga from the MacKenzie and St. Lawrence rivers.

5) PCB, αHCH, and HCB concentrations in ringed seals at Holman Island, NWT have declined since 1972. Organochlorine concentrations in male blubber were higher than in females, because the latter are able to "clear" appreciable amounts of residues during lactation.

6) Results for walrus from southeastern Baffin Island and Foxe Basin indicate unexpectedly high contamination by PCBs, DDT, toxaphene and chlordane compounds in blubber. In males from Inukjuak, Hudson Bay, the levels of these contaminants were 11.8, 5.6, 1.4, and 6.9 μg/g, respectively.

7) High levels of lead were found in walrus from Igloolik, Hall Beach, Iqualuit, Akulivik and Inukjuak, which may be a reflection of the high levels in clams upon which they feed. The highest mean lead concentration (8 μg/g dry wt) was found in walrus liver at Inukjuak.

Lead and mercury concentrations in walrus increased from N to S, whereas cadmium decreased.

8) Non-ortho and mono-ortho PCBs contribute a substantial proportion of TCDD equivalent concentrations in arctic marine mammal and fish samples.

9) Of the organochlorines measured in fish from Yukon lakes in 1992, toxaphene was the most concentrated. The level of this contaminant in Atlin Lake burbot liver (1533 ppb) was so elevated that Health and Welfare Canada issued a health advisory against consumption of this tissue. In 1991, a health advisory was also issued for Lake Laberge, recommending that burbot liver not be consumed and that lake trout be consumed only in limited quantities.

10) All major classes of organochlorine contaminants were detectable in whitefish muscle in lakes and rivers in the Northwest Territories and northern Quebec. Toxaphene was the most concentrated, ranging from 119 to 190 ng/g (lipid weight basis).

11) Levels of organochlorines, especially PCBs (7.3 µg/g) and toxaphene (9.4 µg/g), in landlocked char from Amituk Lake on Cornwallis Island were much higher than in the sea run samples.

Knowledge Gaps

1) There are insufficient data for arctic biota to suggest spatial or temporal trends of contaminants.

2) There is an important lack of standard techniques to reveal early adverse biological effects resulting from contaminant exposure.

3) To better understand the implications of trace organics for the marine ecosystem, more work on food chain structure and trophic interrelationships is required.

4) Metal contamination studies should be enhanced in selected areas.

Future Work

1) An interlaboratory quality assurance (QA) program is being developed for the determination of organochlorines, metals and polyaromatic hydrocarbons in arctic samples by various projects under the Arctic Environmental Strategy, to ensure acceptable levels of accuracy and precision of all analytical results reported by participating laboratories.

2) Non-ortho PCBs will be measured in additional marine and freshwater fish and in whale and seal tissues to develop a larger database than is available at present.

3) Alaskan beluga samples will be analyzed and additional contacts with Russian scientists will be developed so that samples will be forthcoming from the Russian Arctic.

4) Narwhal tissues from animals in the Pond Inlet area will be collected for the purpose of obtaining a database for background, ecosystem health, dietary intake assessment, and temporal trend analysis.

5) Analysis of metal contaminants in ringed seals from 6 geographic locations will be completed for the purpose of background, ecosystem health, and dietary intake assessment, and spatial trend analysis.

6) The exposure of the lichen-caribou-wolf food chain to organochlorine, heavy metal and radionuclide contaminants will be assessed, and the transfer of these contaminants through the food chain will be modelled. Spatial and temporal trends of contaminants in caribou across the NWT will be determined.

7) The exposure of wild mink to organochlorine and heavy metal contaminants and the potential effect on reproduction will be evaluated. Spatial and temporal trends of these contaminants in mink along the Mackenzie River system will be identified.

LONG TERM TRENDS IN ORGANOCHLORINE (OC) RESIDUES IN EASTERN AND WESTERN ARCTIC SEAL BLUBBER

PROJECT LEADER: R.F. Addison, Fisheries and Oceans Canada (with T.G. Smith, Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, B.C.)

CONTRACTOR: A. Dorey, Halifax.

OBJECTIVES: To provide information about long term (approx. 20 yr) changes in DDT-group and PCB concentrations in arctic seal populations, which are a significant part of native diets.

DESCRIPTION:

Marine mammal blubber is used extensively by Inuit communities as a component of subsistence diets. It may be a major source of OCs. Only two "time series" of analyses of OCs in such samples exist: both data sets suggest that DDT-group levels in marine mammal blubber are relatively constant, but that PCBs are declining. It is desirable to extend both data sets to confirm these trends, and to re-analyze the longer term data set using modern methods to provide information about OCs not measured previously.

A population of ringed seal which is hunted by the Inuit community at Holman Is., NWT, has been studied extensively by DFO since the early 1970's. Samples have previously been taken from it and blubber has been analyzed for OC residues. The population was re-sampled in 1989, and blubber samples analyzed for OCs using modern methods; to ensure comparability with previous analyses, selected blubber samples from a sampling in 1981 were re-analyzed using the same methods. This work led to the following conclusions.

As has been shown previously, OC residue concentrations in blubber from male seals was higher than those in females, because the latter are able to "clear" appreciable amounts of residues during lactation. In female ringed seals, p,p'-DDE (the main metabolite of the DDT-group of insecticides) declined from about 0.35 µg/g in 1972 to about 0.20 µg/g in 1981 and 1989. In other words, p,p'-DDE concentrations did not decline between 1981 and 1989, and declined only slightly between 1972 and 1981. In contrast, PCB concentrations (expressed as the sum of individual chlorobiphenyl [CB] congeners) declined from about 3 µg/g in 1972 to approx. 1 µg/g in 1981, and declined further to approx 0.5 µg/g in 1989. Within the PCB group, the most dramatic change was the decline in CB #105, which declined from about 10% of the total CBs in 1981 to about 2% in 1989; its decline was balanced by a slight increase in the more highly chlorinated CBs, most obviously # 153. The decline in # 105 (2,3,4,3',4'-pentachloro-CB) might be due to the presence of adjacent unsubstituted positions which might make this compound more susceptible to degradation via epoxide formation and

hydrolysis. Among other residues, both α-HCH and HCB declined between 1981 and 1989, by about 50% and 70%, respectively.

The rapid decline in PCB concentrations (relative to the DDT-group) is consistent with that observed previously (Addison *et al.*, 1986) and suggests that the world-wide voluntary ban on the manufacture and use of PCBs has resulted in some improvement in the state of contamination by these compounds. The slower decline in DDT-group concentrations is less easy to interpret, but taken together with the relatively rapid decline in the DDT-group seen in eastern Canadian seals, the data suggest that there is some continuing supply of DDT to the Arctic. The declines in α-HCH and HCB concentrations are also difficult to interpret, since little is known of the sources and transport of these materials to the western Arctic.

UTILIZATION OF RESULTS:

The points of most interest in these data are (a) the continued decline of PCB concentrations (and the less rapid decline of the DDT-group) and (b) the apparent selective decline of CB # 105. We propose to continue these studies by:

(i) continuing to sample the Holman Is. ringed seal population in 1992/93 to provide a further "point" on the time series analysis;

(ii) analyzing new samples, and re-analyzing former Holman Is. samples to establish a more comprehensive picture of the changes in CB congener distribution.

Expected project completion date: 1995/96.

RESOURCES:

	1991/92	1992/93
Green Plan AES ($K):	17	40

REFERENCE:

Addison, R.F., T.G. Smith, and M.E. Zinck. 1986. PCBs have declined more than DDT-group residues in Arctic ringed seals (*Phoca hispida*) between 1972 and 1981. Env. Sci. Technol. 20: 253.

SPATIAL TRENDS IN ORGANOCHLORINES IN ARCTIC RINGED SEAL AND WALRUS

PROGRAM LEADER: D. Muir, Fisheries and Oceans Canada, Central and Arctic Region

PROJECT TEAM: D. Muir, B. Grift, C. Ford, and M. Segstro (contractor)

OBJECTIVES:

1. Determine spatial and temporal trends in PCBs and other organochlorines in arctic ringed seal and walrus.

2. Provide data for use in surveys of dietary contamination.

DESCRIPTION:

People in arctic coastal communities consume marine mammals as part of their traditional diets. Information is needed to evaluate current risks of exposure to PCBs via consumption of skin, blubber and other tissues. Surveys have shown the presence of a wide range of organochlorine contaminants in arctic marine mammals throughout the Arctic. There is relatively complete data on organochlorine levels in ringed seals from northern Quebec and the central arctic islands for samples collected in the mid-1980's but data on contaminants in ringed seal from Hudson Bay and from the northern Arctic archipelago is limited. There is little information on geographic trends in other seal species e.g. Bearded, Harp and Harbour seals or on walrus. Furthermore information is also limited on variations of contaminants with age and sex because of small sample sizes analyzed from most locations.

The specific objectives for 1991-92 were (1) to follow up preliminary findings of high PCBs and organochlorine pesticide residues in samples of walrus blubber from eastern Hudson Bay locations sampled as part of the Northern Québec study in 1989-90, by extending the monitoring to other walrus populations and obtaining more samples from northern Québec, and (2) to begin additional studies on ringed seals from other regions.

ACTIVITIES IN 1991/92:

(a) **Samples:** Walrus blubber samples were obtained from Dr. Rob Stewart and colleagues. Samples were from Loks Land (southeastern Baffin Island) and from Igloolik and Hall Beach in Foxe Basin. Samples of walrus were also collected by Makivik Corp. during the 1991 fall hunt at Inukjuak and Akulivik (northern Québec) but we were unable to get a contract to pay for cost of collections due to the restraint program announced at the end of January. It is hoped to contract with Makivik Corp. to obtain these samples in early 1992/93. Ages of the

walrus were determined via a contract with Ms. B. Stewart. Samples of ringed seal were also obtained from Arviat (NWT), on the west coast of Hudson Bay as part of a collaborative study with Ian Stirling (CWS, Edmonton) and R. Mulders (GNWT Renewable Resources, Arviat NWT).

(b) **Methods:** Walrus samples were analyzed for PCB congeners and organochlorine pesticides (hexachlorocyclohexanes (HCH), toxaphene (PCCs), chlordane, and the DDT group). The extraction and separation of analytes from lipid coextractives were the same as those described in Muir *et al.* (1990; 1992) and are described in the report on Circumpolar survey of PCBs in Beluga".

(c) **Quality assurance:** Internal standard recoveries (aldrin and octachloro-naphthalene) were uniformly greater than 90%. A Cod liver standard reference material (SRM-1588) from National Institute of Standards and Technology (Gaithersburg, Va) was analyzed for major organochlorine pesticides and PCB congeners. During the period over which the beluga blubber were analyzed the laboratory took part in an ICES (International Council for Exploration of the Sea) interlaboratory comparison of PCB congeners in seal blubber.

RESULTS:

Preliminary results from the analysis of walrus blubber from Inukjuak in 1990 showed elevated levels of most organochlorine contaminants (Table 1). Levels of ΣCHLOR, ΣDDT and ΣPCB in walrus were similar to those reported in narwhal, beluga and polar bear fat and much higher than reported by Born *et al.* (1981) who found 360±310 ng/g PCBs (measured as Aroclor 1254) in blubber of walrus from western Greenland. The levels in samples from Alulivik, further north on east Hudson Bay, were more in the range of those reported previously. Work was undertaken during 1991/92 to confirm that the samples were indeed from walrus. The samples had been well labelled and shipped frozen by Stas Olpinsky of Makivik Research Corp so misidentification due to labelling was ruled out. Examination of the jaws showed that they were indeed from walrus. Carbon-13 and nitrogen-15 isotope measurements, performed by Dr. Keith Hobson (DFO Winnipeg) using muscle samples from the jaws, showed that walrus with high ΣPCB had more negative $\delta^{13}C$ values than those with low PCBs. The more negative $\delta^{13}C$ value indicates that the walrus are feeding on a pelagic marine food source rather than a benthic source. The results suggest that these walrus are feeding on ringed seals rather than on clams.

PCBs and organochlorine pesticide levels in walrus blubber from Igloolik and Hall Beach were 20-times lower than in the Inukjuak animals (Table 1) consistent with results expected for benthic feeding animals and with results of Born *et al.* (1981). Of the six

Table 1. Concentrations of PCBs and other organochlorines in walrus from northern Québec, Foxe Basin and Cumberland Sound areas.

Location	Sex	N	Age	Concentration (ng/g wet wt)			
			(yrs)	ΣCHLOR	ΣDDT	ΣPCB	PCC
Inukjuak	F	7	1-23	3300±2750	2660±2020	5250±4600	758±494
	M	2	11-23	6930	5580	11800	1350
Akulivik	M+F	3	2-12	3510±328	194±238	446±388	363±102
Loks Land	M+F	6	8-14[1]	1790±1990	518±635	1400±1450	130±94
Hall Beach	M	6	?	314±44	38±6.1	206±43	177±41
Igloolik	M	6	?	311±85	28±9.1	192±53	167±55

[1]Ages available for 4 of 6 animals

samples analyzed from Loks Land walrus, three had levels similar to those at Igloolik/Hall Beach (mean = 219 ng/g) and three had 10-fold higher levels (mean = 3060 ng/g). Age does not seem to be a major factor influencing the levels in walrus. High levels were observed in two young female animals (0-1 yr) from Inukjuak, possibly due to transfer from mother's milk.

CONCLUSIONS AND UTILIZATION OF RESULTS:

The results for walrus indicate unexpectedly high contamination by PCBs, ΣDDT, PCC (toxaphene) and chlordane compounds in blubber of 12 of the 30 animals analyzed to date. The preliminary conclusion is that these walrus are feeding on ringed seals for a significant portion of their diet. Consumption of seal by walrus has been observed but it has been thought to be limited to a small number, perhaps 10%, of rogue animals. The present results suggest this is more common than previously thought. These results have implications for assessment of dietary exposure via consumption of walrus tissues. Additional work will be done during 1992/93 to characterize the frequency of high organochlorine contamination of walrus and to examine levels in clams which are thought to form the bulk of the diet for these animals. Work will also begin on analyses of ringed seals from Arviat on a detailed study of variation in contaminant levels with age and sex. Ringed seals will also be obtained from Resolute as part of food chain studies in collaboration with B. Hargrave.

Expected project completion date: March 31, 1997.

Partners: Makivik Research Corp., Kuujuak Qué, GNWT Renewable Resources

RESOURCES: (received in 1991/92, 1992/93 and planned under the Green Plan AES)[1]

	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
Total ($K)	20	25	25	20	20	20

[1] This project will be combined with B.3.3 "Circumpolar survey of PCBs in beluga" for 1992/93 - 1996/97.

REFERENCES:

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Muir, D.C.G., C.A. Ford, N.P. Grift, R.E.A. Stewart and T.F. Bidleman. 1992. Organochlorine contaminants in narwhal (*Monodon monoceros*) from the Canadian arctic. Environ. Pollut. 75: 307-316.

LEAD AND OTHER HEAVY METALS IN TISSUES OF WALRUS AND RINGED SEALS

PROGRAM LEADER: R. Wagemann, Fisheries and Oceans Canada

PROJECT TEAM: R. Stewart, Fisheries and Oceans Canada, Winnipeg
S. Opinski, Makivik Research Centre, Kuujjuaq, Québec
D. Savoie and B. Stewart (contractors), Fisheries and Oceans Canada, Winnipeg

OBJECTIVES:

1. To measure and assess toxic metals (lead, cadmium, mercury) in tissues of walrus from the Canadian Arctic and northern Quebec for the purpose of providing a data base for estimates of dietary intake of toxic metals by native people and ecosystem health studies.

2. To measure and assess toxic metals in tissues of marine mammals from the Canadian Arctic and northern Quebec for the purpose of obtaining background data for different geographic locations, times, and species, in order to determine spatial and temporal trends and inherent differences of metal contaminants among different species of marine mammals.

PROJECT DESCRIPTION:

Introduction

Anomalously high heavy metal levels have been found in some marine mammals. For example, mercury concentrations in beluga (Wagemann *et al.* 1990) were significantly higher than the Federal Guideline of 0.5 ppm (wet weight basis). Ringed and bearded seals in the vicinity of Holman on Victoria Island N.W.T. (Smith and Armstrong, 1975) had extraordinarily high mercury levels in liver. Lead was high in some ringed seals from the Strathcona Sound area N.W.T. (Wagemann, 1989). Narwhal from the vicinity of Pond Inlet N.W.T. had some of the highest concentrations of cadmium in liver and kidney found to date in any group of marine mammals (Wagemann *et al.* 1983). Except for beluga, metals data are still sparse for most marine mammals from the Canadian Arctic. There were no metals data available for walrus from the Canadian Arctic prior to this study. The study was extended from the three geographic locations reported on last year (Igloolik, Hall Beach and Frobisher Bay (Iqaluit) to five locations (Inukjuak, Akulivik) during the past year. The walrus data reported here comprise a fairly substantial geographic data base providing the basis for determining spatial trends, ecosystem and human health, and dietary intake calculations as well as being a bench-mark for other studies (e.g. Hydro-Quebec

projects). Additional samplings will be required in the future to deduce temporal trends. Additionally, clams were obtained from the Igloolik area and analyzed.

Completed Analyses

Liver, kidney and muscle tissues from well over 100 walrus were taken at five locations between 1982 and 1990: Igloolik (72 animals, 1982-88), Hall Beach (16 animals, 1988), Frobisher Bay-Iqaluit (30 animals, 1983-88), Inukjuak (9 animals, 1990), Akulivik (4 animals, 1990). Tissues were analyzed (some repeatedly) for lead, cadmium, mercury, selenium, zinc and copper, involving well over 2500 analyses. Only liver tissue samples were obtained from the latter two locations (Inukjuak, Akulivik) and were analyzed for metals and Se during the past year. The analysis of available walrus tissues has been completed as far as samples in hand are concerned, but additional samples are needed for temporal trend analysis. The combined set of data for all five stations are presented.

RESULTS:

Mean metal concentrations in tissues (dry weight basis) of walrus for each location (Tables 1-3) were obtained by taking the arithmetic average of all the individual values for each animal at a particular location. These can be converted to a wet weight basis by multiplying with the following factors: 0.299 for liver; 0.232 for kidney; 0.266 for muscle. Clams (which are the main food of walrus) were dissected into three (or two) tissue groups and analyzed for the five metals in question (Table 4). The tissues were not rinsed at any stage in order to reflect the same condition they were in when ingested by walrus. The concentration of lead was high in clam tissues, particularly in the sheath of *Mya truncata* where it was an order of magnitude higher than in other tissues. Some particulate matter adhering to the sheath was analyzed with the tissues. Mercury concentrations in both *Mya truncata* and *Serripes groenlandicus* were extremely low. Cadmium concentrations were also low in all the clam tissues.

Lead:

Compared to some other marine mammals (arctic belugas, narwhal) lead was relatively high in walrus from all five locations, and in animals from Inukjuak it was as high as in belugas from the St. Lawrence. The St. Lawrence belugas can be considered a reference for lead in marine mammals from a polluted aquatic system. While there was no significant difference among the means of animals from the three most northern locations (Igloolik, Hall Beach, Frobisher Bay), there was a significant difference between these groups and those from the two most southern locations (Inukjuak, Akulivik) for lead in liver. The mean concentration of lead in the liver was twice as high in animals from Inukjuak than in animals from Igloolik or Hall Beach. Kidney was not analyzed for lead and was not always available. A spatial trend of lead in liver is evident

amongst the five groups (Fig. 1), with concentrations increasing from north to south. A comparison with published data of other marine mammals (arctic belugas, narwhal, ringed seals) showed that arctic marine mammals have significantly less lead than walrus from the five locations investigated. The relatively high concentration of lead in walrus from all locations may be largely a consequence of the relatively high lead in clam tissues (Table 4).

Mercury:
Mercury in liver showed a similar spatial trend to that of lead, increasing from north to south (Fig. 2). Although there was no significant difference in the mercury concentration among the most northern groups for any of the three tissues, the liver concentration in animals from Inukjuak was nearly twice as high as in animals from Igloolik and Hall Beach. However, liver mercury means for walrus from all five locations were lower than for other arctic marine mammals (arctic beluga, narwhal, ringed seals), and certainly much lower than for belugas from the St. Lawrence. In muscle, none of the group means exceeded the Federal Guideline of 0.5 ppm (wet wt), and the overall mean of all groups was 0.11 ppm (wet wt). The low mercury concentrations in walrus tissues are very likely a reflection of the very low mercury levels in mussel tissues.

Cadmium:
The spatial trend for cadmium in walrus liver was found to be opposite that for lead and mercury, namely decreasing from north to south (Fig. 3). This is in line with previous findings for other marine mammals. Cadmium was very low in belugas from the St. Lawrence and very high in narwhal from the Pond Inlet area. Compared to other arctic marine mammals, cadmium in walrus, although not as high as in narwhal, was very high in the kidney (56.6 µg/g, wet wt) and comparatively high also in the liver. Similar to the other metals, there was no significant difference in the mean cadmium concentration among the northernmost group means but these were twice as high as the group from the Inukjuak area. Mussels appear not to be the main source of cadmium for these walrus judging by the relatively low concentration of cadmium found in all the mussel tissues analyzed.

Selenium:
The selenium levels in walrus were similar to those found in other marine mammals. There was no significant difference among the means from the five locations. As in other marine mammals there was a very significant positive correlation between mercury and selenium in the liver. The biochemical significance of this association is still not well understood. The kidney was not analyzed for selenium.

Zinc and Copper:
These metals were measured in walrus liver, kidney and muscle tissues (when available). Since zinc is an essential element it was expected that its concentration would not differ significantly among the different groups of walrus; it did not, and the levels

were quite comparable to those found in other marine mammals. Copper, being an essential element also, was expected to behave similarly to zinc. However, the means for copper in liver for the two most southern groups (Inukjuak, Akulivik) were higher than those for the northern groups. The significance of this difference is not known, except that it may indicate more copper being available to the walrus at the most southern locations.

SUMMARY:

1. Clam tissues (which are the main food of walrus) were dissected into three (or two) tissue groups and analyzed. The tissues were not washed in order to reflect their condition when ingested by walrus.

2. Lead was found to be relatively high in the clam tissues; in the sheath it was enormous. The relatively high lead levels in walrus tissues may be a reflection of the high levels in clams. Some particulate matter may have been present in the clam tissues, possibly contributing some lead to the measured lead concentrations.

3. Mercury levels in the walrus tissues examined were quite low, in accord with the low levels of mercury found in clams tissues.

4. Cadmium levels in the walrus tissues examined were relatively high, but in clam tissues cadmium was quite low. This suggests that clams may not be the main source of cadmium in walrus.

5. For lead and mercury in walrus a spatial trend of increasing concentration from north to south was indicated in animals from different geographic locations.

6. For cadmium in walrus a spatial trend of decreasing concentration from north to south was indicated in animals from different geographic locations.

7. The trend findings are tentative until validated or refuted by analysis of additional samples from appropriate locations.

Expected Project Completion Date: Phase 1 (Walrus)-1991/92; Phase 2 (Ringed seals)-1993/94; Phase 3 (Narwhal, walrus from N. Quebec, beluga)- 1993/97.

LAST YEAR'S ACCOMPLISHMENTS (1991/92):

1. Obtained additional walrus tissues from two geographic locations in northern Quebec.

2. a. Analysis of all available walrus tissues from 5 geographic locations completed, providing an extensive data base of metal contaminants in walrus for the purpose of background, ecosystem health, and dietary intake assessment and spatial trend analysis.

   b. Contractor completed age determinations of animals for which teeth were available.

   c. Statistical analysis of walrus data nearly completed.

3. a. Submitted final report (this report) to DIAND on walrus.

   b. Results of walrus investigation readied for publication in scientific journal.

WORK PROPOSED FOR NEXT YEAR (1992/93):

1. Analysis of metal contaminants in ringed seals from 6 geographic locations will be completed for the purpose of background, ecosystem health, and dietary intake assessment, and spatial trend analysis.

2. A report on ringed seal investigation will be submitted to DIAND.

3. Narwhal tissues from animals in the Pond Inlet area will be obtained (circumstances permitting) as part of Native hunts during the summer and fall of 1992, for the purpose of obtaining a data base for temporal trend analysis, background, ecosystem health, and dietary intake assessment. The last narwhal sample, the only one available from the Canadian Arctic thus far, was obtained 12 years ago. This is insufficient for temporal or spatial trend analysis.

4. Additional samples of belugas will be required in 2-3 years (5-6 years after the last sampling in 1988) to deduce temporal trends.

RESOURCES: (received in 1991/92, 1992/93 and planned under Green Plan AES)

	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
$K	26	35	20	30	35	30	10

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Table 1. Mean metal concentrations μg/g (dry wt), standard deviations, number of samples and ranges, in liver of walrus from Igloolik, Hall Beach, Frobisher bay, Akulivik and Inukjuak.

IGLOOLIK

	Pb	Cd	Zn	Cu	Hg	Se
Mean	0.26	37.6	152	34.6	4.42	9.22
SD	0.22	24.2	34.8	23.7	3.73	4.09
n	81	70	70	70	69	68
Range	0.05-1.5	0.1-137	50-300	6.4-88.8	0.03-5.1	2-20

FROBISHER BAY

	Pb	Cd	Zn	Cu	Hg	Se
Mean	0.33	37.4	152	32.3	4.94	10.2
SD	0.27	19.8	33.2	34.5	3.14	3.03
n	31	30	30	30	31	30
Range	0.06-0.46	0.1-98	107-268	6.2-137	0.81-16	3-16

HALL BEACH

	Pb	Cd	Zn	Cu	Hg	Se
Mean	0.23	37.7	148	22.5	4.35	10.2
SD	0.11	16.1	37.7	11.0	4.04	3.91
n	17	16	16	16	16	16
Range	0.09-0.5	13-76	94-215	8.6-46	1.7-17	5.4-18

Table 1. continued

AKULIVIK

	Pb	Cd	Zn	Cu	Hg	Se
Mean	0.42	29.9	142	48.5	4.24	8.20
SD	0.10	23.0	89.4	12.7	3.16	4.58
n	4	4	4	4	4	4
Range	0.27-0.50	7.6-51	115-183	35-61	1.79-8.8	3.7-15

INUKJUAK

	Pb	Cd	Zn	Cu	Hg	Se
Mean	0.56	18.6	135	49.1	8.00	9.17
SD	0.57	14.8	51.0	28.3	6.03	3.07
n	9	9	9	9	9	9
Range	0.15-1.9	0.1-41	69-248	8.6-85	0.5-16	3.5-13.5

Table 2. Mean metal concentrations μg/g (dry wt), standard deviations, number of samples and ranges, in kidney of walrus from Igloolik, Hall Beach and Frobisher bay.

IGLOOLIK

	Pb	Cd	Zn	Cu	Hg	Se
Mean	---	235	164	24.5	1.28	---
SD	---	136	33.9	11.7	0.52	---
n	---	68	68	68	68	---
Range	---	0.1-564	70-225	11-104	0.32-3.2	---

FROBISHER BAY

	Pb	Cd	Zn	Cu	Hg	Se
Mean	---	254	170	20.5	1.50	---
SD	---	103	32.8	7.11	0.50	---
n	---	28	28	28	26	---
Range	---	0.1-421	85-216	9.2-42	0.46-2.7	---

HALL BEACH

	Pb	Cd	Zn	Cu	Hg	Se
Mean	---	263	175	18.9	1.40	---
SD	---	96.1	29.4	3.62	0.44	---
n	---	16	16	16	16	---
Range	---	84-507	116-208	13-26	0.81-2.3	---

Table 3. Mean metal concentrations μg/g (dry wt), standard deviations, number of samples and ranges, in muscle of walrus from Igloolik, Hall Beach and Frobisher bay.

IGLOOLIK

	Pb	Cd	Zn	Cu	Hg	Se
Mean	0.092	0.53	168	3.43	0.35	12.9
SD	0.22	0.53	30.2	1.07	0.28	6.23
n	68	69	69	69	69	68
Range	0.01-1.7	0.05-1.8	116-264	1.87-7.1	0.06-1.1	1.9-28

FROBISHER BAY

	Pb	Cd	Zn	Cu	Hg	Se
Mean	0.063	0.52	180	2.82	0.57	12.8
SD	0.043	0.37	36.8	0.59	0.88	3.72
n	28	28	28	28	28	28
Range	0.02-0.16	0.05-1.5	85-247	1.8-4.1	0.22-5.0	5-20

HALL BEACH

	Pb	Cd	Zn	Cu	Hg	Se
Mean	0.043	0.46	174	3.10	0.50	10.2
SD	0.024	0.38	15.4	0.45	0.18	6.12
n	16	16	16	16	16	16
Range	0.01-0.1	0.05-1.5	146-203	2.44-3.78	0.27-0.81	4.1-28.4

Table 4. Average trace metal concentrations (μg/g wet wt) in different clam tissues from the vicinity of Igloolik.

Mya truncata

TISSUE	Pb	Cd	Hg	Cu	Zn
Siphon	0.15±0.08 n=8	0.21±0.13 n=12	0.007±0.005 n=7	0.7±0.4 n=12	9.9±3.2 n=12
Sheath	3.33±1.75 n=11	0.16±0.12 n=11	≤.005 n=7	6.8±3.7 n=11	15.8±4.2 n=11
Inards	0.23±0.26 n=11	0.34±0.17 n=11	≤.005 n=7	2.1±0.6 n=11	16.7±3.8 n=11

Serripes groenlandicus

TISSUE	Pb	Cd	Hg	Cu	Zn
Inards	1.67±0.79 n=6	0.14±.04 n=6	0.021±0.001 n=3	2.6±0.8 n=6	21.8±8.7 n=6
Foot	0.31±0.06 n=6	0.03±0.03 n=6	0.020±0.004 n=3	0.5±0.1 n=6	15.8±2.5 n=6

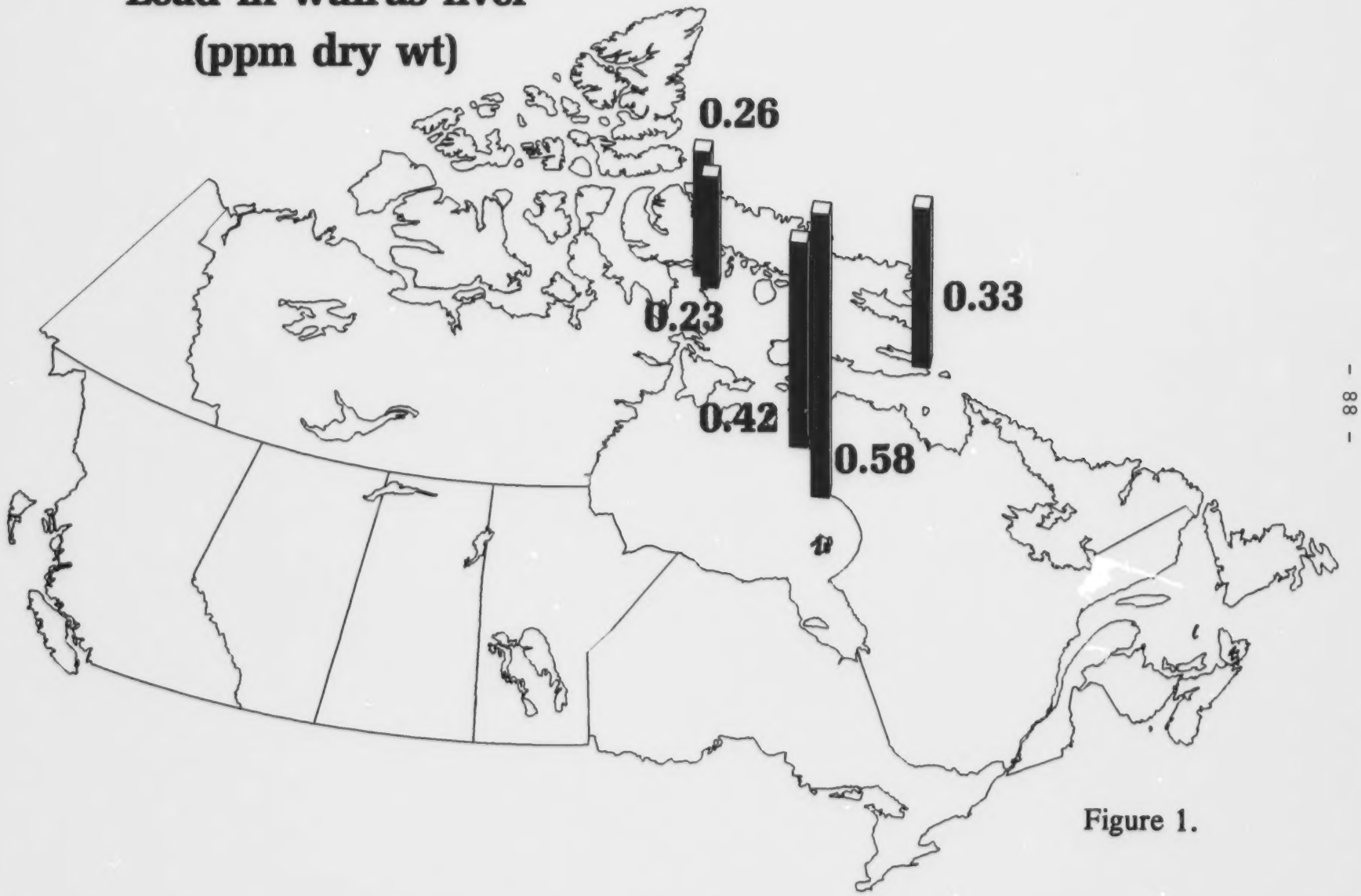

Figure 1.

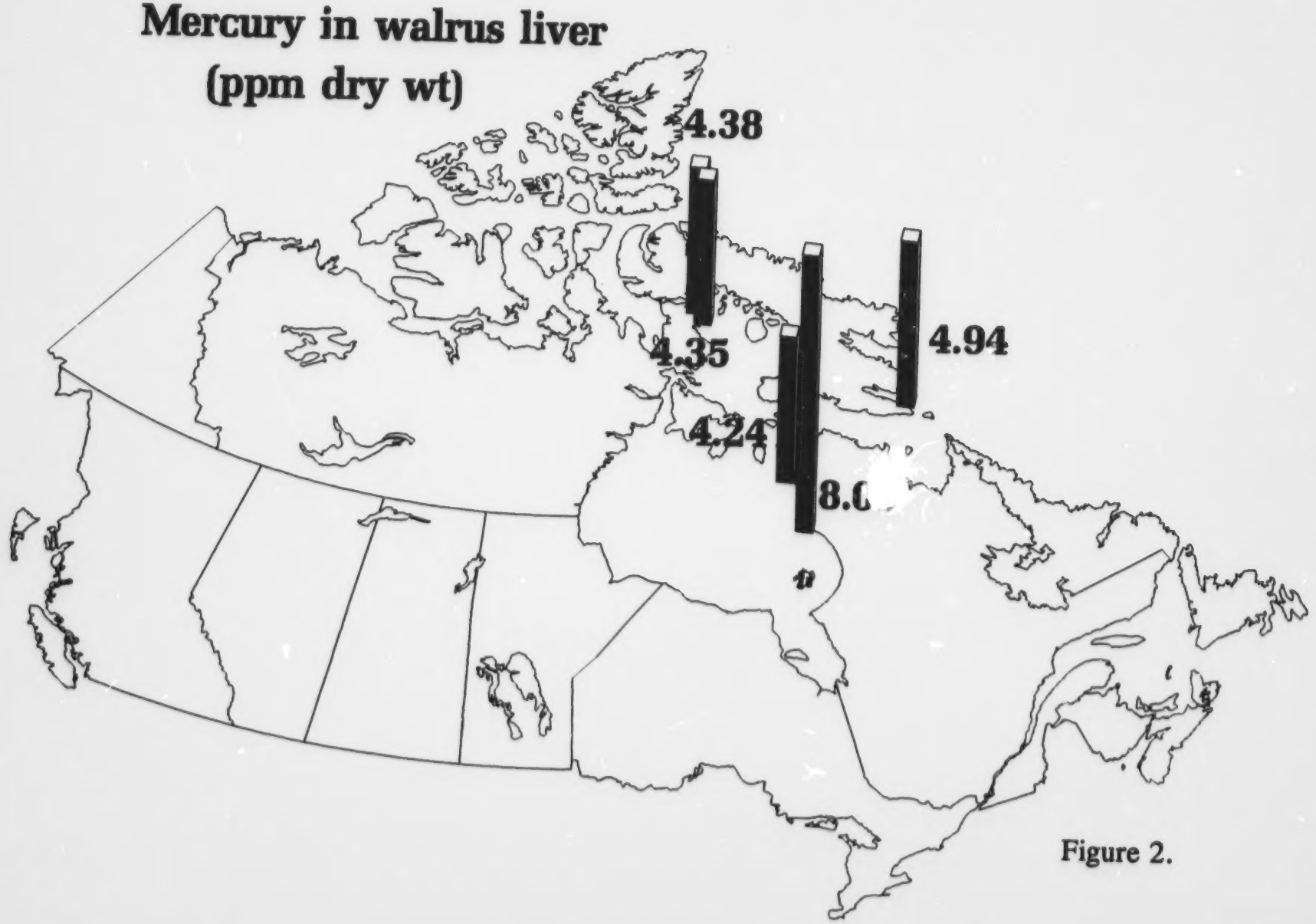

Figure 2.

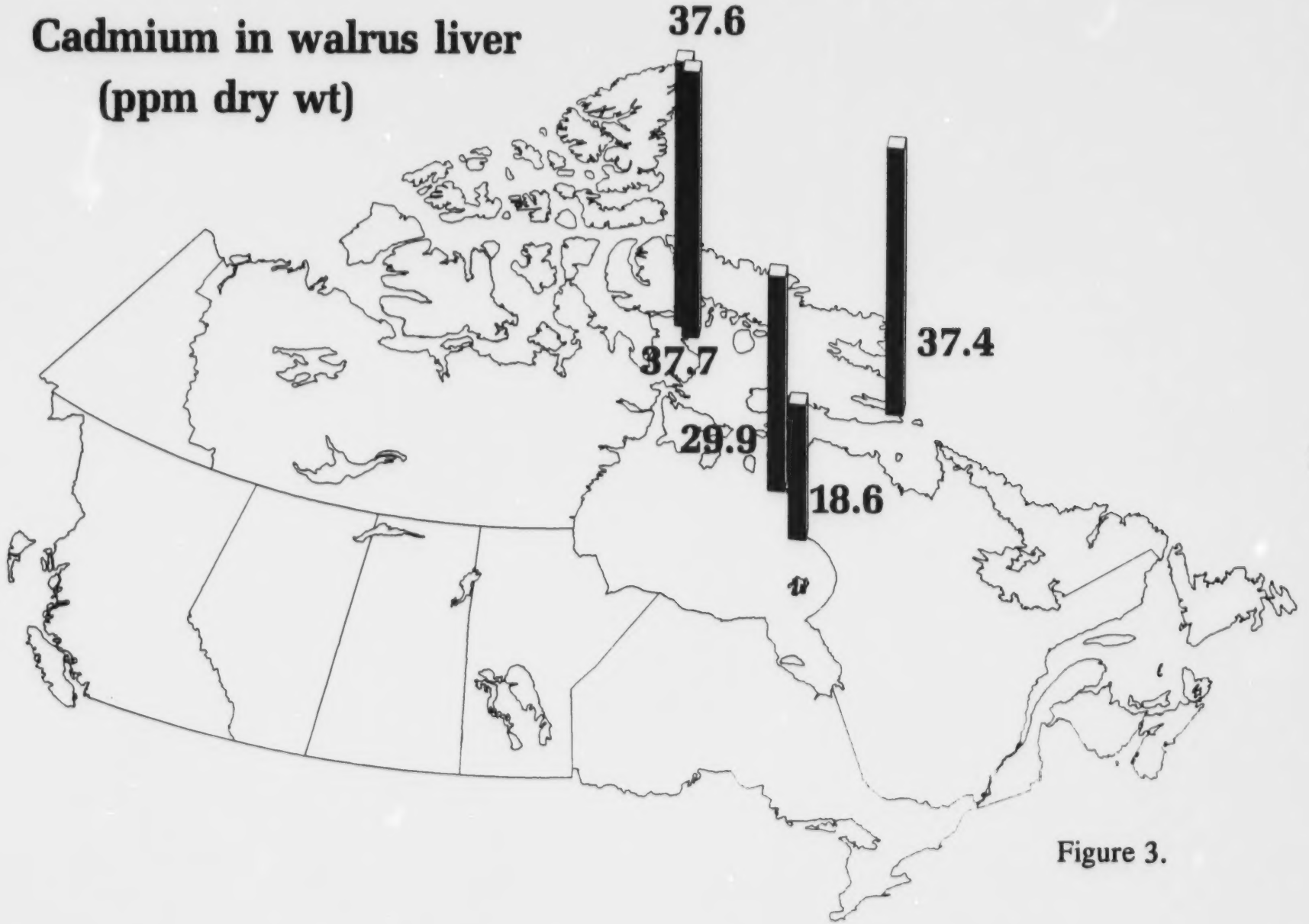

Figure 3.

METALLOTHIONEINS IN ARCTIC MARINE MAMMALS AND FISH

PROGRAM LEADER: R. Wagemann, Fisheries and Oceans Canada

PROJECT TEAM: J.F.K. Klaverkamp, G. Boila, L. Wesson, J. Hiebert (contractor)

OBJECTIVES:

1. The initial objective is to develop a data base of natural levels of metallothionein in marine mammals and fish in the wild, and to delineate the influence of environmental and biological factors on the level of (MT) in animals. This will provide geographic and species reference information for screening purposes in biomonitor and ecosystem health studies.

2. In the longer term to determine the metal composition of metallothioneins in marine mammals and fish from different geographic locations. Information on compositional changes with location, species, and age and sex of animals is required for delineating potential stressors.

   These objectives were supported in the Arctic Contaminants planning Workshop, Burlington, April 3-4, 1991.

PROJECT DESCRIPTION:

Introduction

Metallothionein (MT) is a low-molecular weight, ubiquitous protein. It occurs naturally in most living organisms but tissue levels can vary greatly in response to a number of stressors, notably heavy metals, but also diseases, stress, and some nonmetallic substances and additionally is a specific indicator of toxic versus nontoxic cadmium. Among mammalian metallothioneins two major forms are usually found called isometallothioneins which show small genetically determined differences in their primary structure and are not simply due to differences in metal composition. The metal composition of metallothioneins is determined primarily by local physiological and environmental circumstances. The role of metallothionein in the protection of organisms from metal toxicity, its potential for environmental monitoring as well as the induction of its synthesis primarily in response to heavy metal exposure, has been studied fairly extensively. Only Mt is protective during heavy metal exposure, but extracellular Cd-MT is a potent nephrotoxin, and does not confer any protection from metal toxicity to consumers of tissues containing metallothionein. Measurement of MT can be an integrative stressor indicator and may be used as a quick, primary

screening tool to indicate if more specific and less integrative tests are needed. The basic metallothionein measurement can be done quickly and economically. This project will develop a data base which will show how environmental and biological factors influence natural levels of metallothionein in animals in the wild, a prerequisite for its application as a biomonitor. Metallothionein, in addition to providing an integrative response to a range of stressors, is a specific indicator of toxic versus nontoxic cadmium.

Completed Analyses

Liver, kidney, gill, and intestine tissues from over 100 fish, taken at four different locations (ELA, Saqvaqjuac, Resolute, Hazen lake), were analyzed for metallothionein. Additionally, liver tissue from 5 harp seal mothers and their pups were analyzed for metallothionein. The metal composition of harp seal metallothionein was determined, using chromatographic techniques and metal analysis of the fractions.

RESULTS:

Mean metallothionein concentrations in fish ranged from 7 to 475 µg/g (wet wt) depending on the type of tissue and location, Table 1. The metallothionein concentration in liver, kidney and gill tissues of fish appeared to be latitude dependent, decreasing from south to north, Figures 1-3. The exception was the most northern location, Hazen lake on Ellesmere Island. Fish from this location had higher concentrations of metallothionein than indicated by the trend. This lake is known to be underlain by coal deposits, and high concentrations of PAH's are found in these lake sediments. It is possible that induction of metallothionein is increased by exposure to PAH's.

The metallothionein concentration in liver of harp seal pups was comparable to that of their mothers (174, 145 µg/g respectively), Figure 4. The metallothionein concentration in the livers of adults increased with age, Figure 5. The pups ranged from 2 to 10 days in age and were still feeding solely on mother's milk and there was no evidence of metallothionein dependence on age. The mothers ranged in age from 7 to 20 years. The metal composition of mother and pup metallothionein was quite different, Table 2. In pups it consisted only of the essential metals in approximately equal proportions i.e 49 % Cu, 51 % Zn. In mothers, metallothionein contained only little zinc, some cadmium, and primarily copper i.e. 13 % Zn, 14 % Cd, 72 % Cu. The metal composition of metallothionein is determined by physiological and local environmental conditions. Some tentative conclusions can be reached on the basis of these compositions.

1. Although cadmium-metallothionein was present in the liver of mothers it was not transferred to their pups.

2. The placenta appears to be an effective barrier to cadmium and cadmium-metallothionein.

3. Adult harp seals were exposed to biologically available cadmium in their feeding environments, and the cadmium in tissues is largely sequestered by metallothionein.

4. Zinc is apparently being replaced by cadmium in metallothionein as harp seals age.

SUMMARY:

1. A spatial trend, decreasing from south to north, in metallothionein in fish from different latitudinal locations was indicated. The exception was Hazen lake. The relatively high values there may be related to the high PAH's in Hazen lake sediments.

2. Fish metallothionein data have not been analyzed for the influence of age and sex on Mt levels; trend indications are therefore only tentative and may change with additional information.

3. Harp Seal pups (Gulf of St. Lawrence) even at the young age of 2-10 days had approximately the same level of metallothionein in their livers as their mothers.

4. Liver metallothionein increased in mothers with age but not in pups during the time span of 2 - 10 days.

5. The metal composition of metallothionein was quite different in pups and mothers. Pup Mt contained only essential metals, approx. 49 % Cu and 51 % Zn. Mother Mt contained 14 % Cd, and only 13 % Zn, and much more Cu (72 %) than pup Mt. The presence of Cd (an unessential element) in Mt of adults points to a substitution of Zn by Cd with age and the environmental availability of Cd.

Expected Project Completion Date: 1995/96

LAST YEAR'S ACCOMPLISHMENTS (1991/92):

1. Instrument installation and methodology development for metallothionein measurement in tissues by two techniques: mercury displacement and differential pulsed polarography.

2. Determination of metallothionein in liver, kidney, gill and intestine of fish from different geographic locations.

3. Determination of liver metallothionein in a sub-sample of available harp seal mothers and their pups.

4. Submitted report to DIAND on metallothionein investigation.

WORK PROPOSED FOR NEXT YEAR (1992/93):

1. Complete determination of metallothionein in remaining available samples of harp seal mother and pup tissues.

2. Collect marine mammal and fish tissues for metallothionein analysis.

3. Determine metallothionein in collected tissues for the purpose of obtaining indication of range of natural metallothionein levels in animals in the wild, and as a reference base for biomonitoring and contaminant effects studies.

4. Submit report to DIAND on metallothionein investigation.

RESOURCES: (received in 1991/92, 1992/93 and planned under Green Plan AES)

	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
$K	25	24	40	40	15	15

Table 1. Mean metallothionein concentration (μg/g) in lake char *Salvelinus namaycush* and Arctic char *Salvelinus alpinus*, standard errors, and sample sizes ( ) from different geographic regions in Canada.

REGION	KIDNEY	LIVER	GILL	INTESTINE
ELA*	74.0 ± 15.5 (24)	475 ± 99 (24)	25.5 ± 4.5 (24)	No Data
Saqvaqjuac*	21.2 ± 3.4 26	315 ± 41 (26)	10.9 ± 1.1 (26)	15.5 ± 2.5 (26)
Resolute‡	8.9 ± 1.5 (39)	154 ± 18 (32)	7.3 ± 0.5 (39)	31.9 ± 3.0 (38)
Hazen Lake‡	25.0 ± 1.7 (45)	354 ± 26 (44)	No Data	75.0 ± 4.4 (45)
% of ELA value Sagvaktuak Resolute Hazen Lake	% 29 12 44	% 66 32 75	% 43 29 No Data	% --- --- ---

* Lake char
‡ Arctic char

Table 2. Metals composition of metallothionein in mother-pup harp seals.

Mothers			Pups		
%Cu	%Cd	%Zn	%Cu	%Cd	%Zn
72 ± 7	14 ± 5	13 ± 3	49 ± 15	0	51 ± 15

Metallothionein in fish liver
(ug/g wet wt)

Figure 1.

Figure 2.

Figure 3.

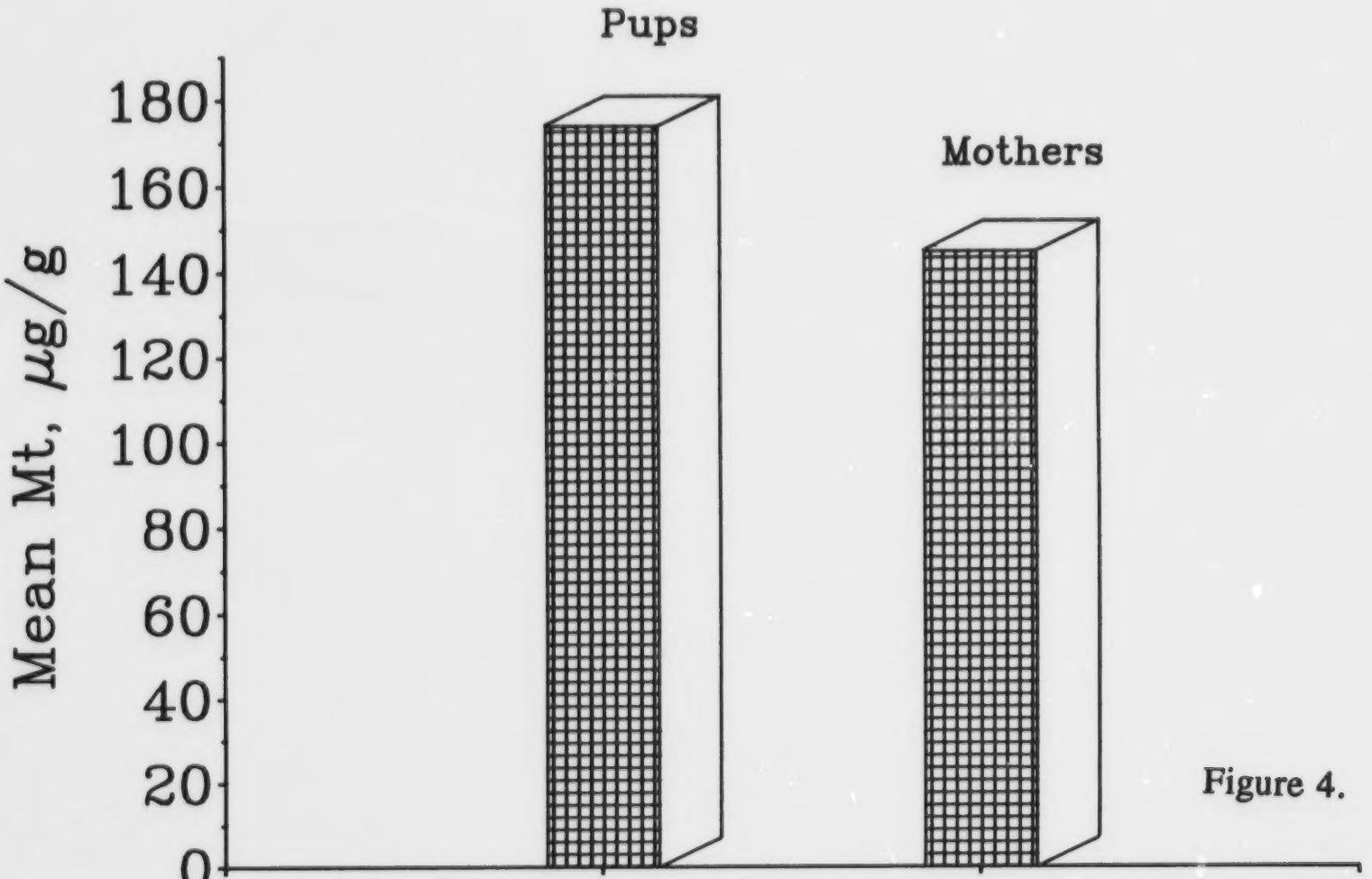
Metallothionein in Harp Seal Livers
Pups
Mothers
Mean Mt, µg/g
180
160
140
120
100
80
60
40
20
0

Figure 4.

Metallothionein in Harpseal Mothers

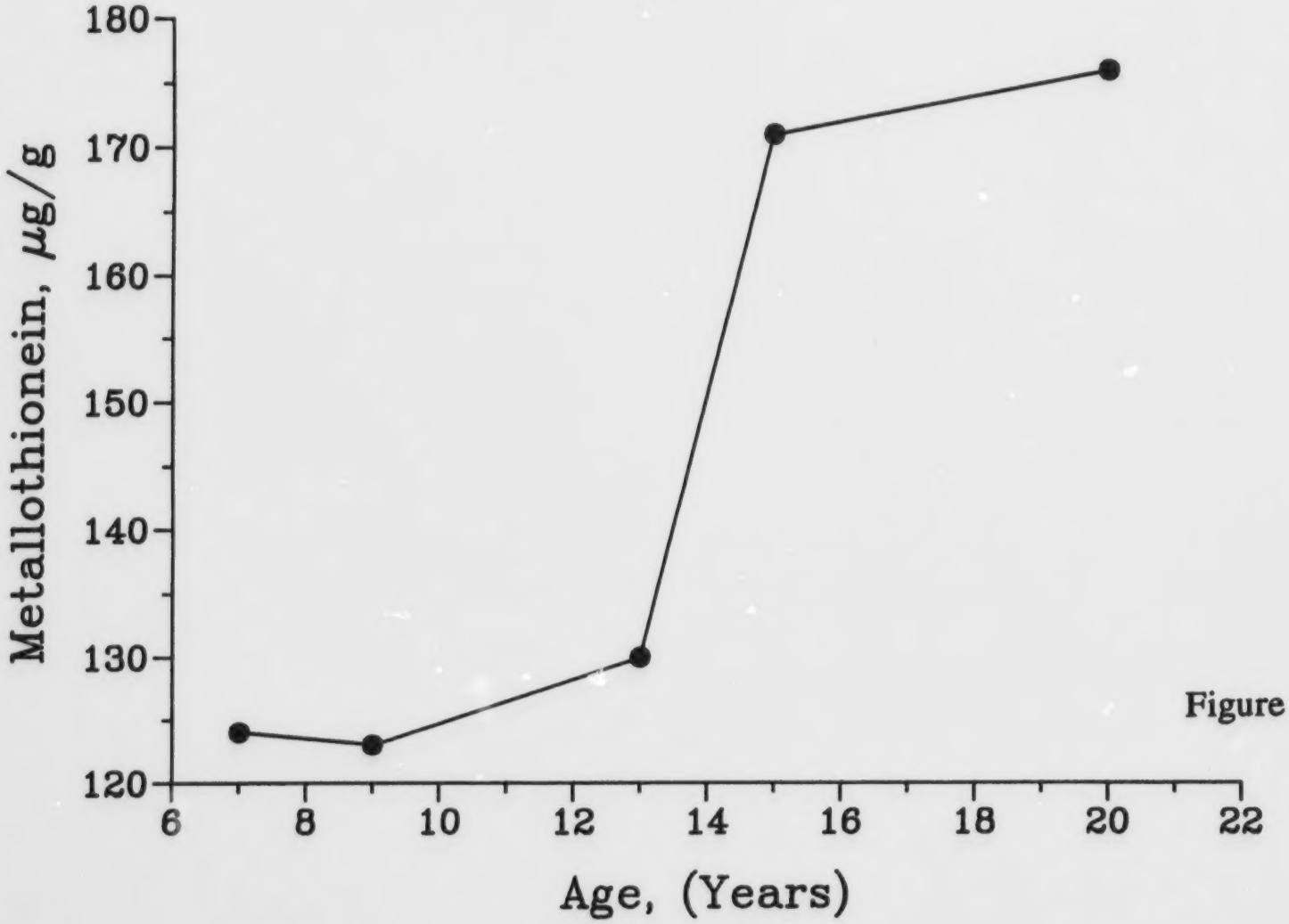

Figure 5.

ORGANOCHLORINE CONTAMINANTS IN BELUGA WHALES OF THE BEAUFORT SEA REGION

PROGRAM LEADERS: Axys Analytical Services Ltd.

PROJECT TEAM: D. Thomas, C. Hamilton, Axys Analytical Services Ltd., Sidney, BC

OBJECTIVES:

Improve the database for organochlorine contaminants in beluga whales of the Beaufort Sea Region.

ACTIVITIES IN 1991/92:

Samples of beluga whale blubber were collected by Inuit hunters during routine hunting activities during 1989 and 1990 at the Shingle Point, West Whitefish Station and Tuktoyaktuk Whaling camps on the Beaufort Sea coast. Only samples from the East Whitefish Station and Kendall Island are reported for the current period. Samples were analyzed for Σ chlorobenzenes (dichlorobenzene, trichlorobenzene, tetrachlorobenzene, pentachlorobenzene, hexachlorobenzene), Σ HCH, Σ chlordanes (sum of trans-chlordane, cis-chlordane, heptachlor, heptachlor epoxide, oxychlordane, trans-nonachlor, cis-nonachlor), Σ DDT (sum of 2,4′-DDE, 4,4′-DDE, 2,4′-DDD, 4,4′-DDD, 2,4′-DDT and 4,4′-DDT), toxaphene, Σ PCBs (sum of approximately 80 individual congeners), mirex, heptachlor epoxide, α-endosulphan, dieldrin, endrin and methoxychlor.

RESULTS:

Results are given in Table 1. Concentrations of organochlorines were generally similar to the results reported by Muir *et al.* (1990) for beluga whale blubber samples collected during 1983 to 1987. The pattern of occurrence of PCB homologues was also similar between the samples of this study and the 1983-1987 samples. The organo-chlorines occurred in beluga whales in the order Σ DDT > Σ PCB, toxaphene > Σ chlordanes > Σ chlorobenzenes > Σ HCH, dieldrin > mirex > methoxychlor > endrin. The ratio of DDE TO Σ DDT was 0.46±0.07.

REFERENCE:

Muir, D.C.G., C.A. Ford, R.E.A. Stewart, T.G. Smith, R.F. Addison, M.E. Zinck and P.E. Béland. 1990. Organochlorine contaminants in beluga, *Delphinapterus leucas* from Canadian waters. Canadian Bulletin of Fisheries and Aquatic Sciences 224: 165-190.

TABLE 1. Organochlorine contaminants in beluga whales from the Beaufort Sea region. (concentrations in $ng.g^{-1}$ wet weight)

AAS 1188

	Sex	Length (m)	% Lipid	Σ ChB	Σ HCH	Σ Chlord.	Σ DDT	Tox.	Cl_3	Cl_4	Cl_5	Cl_6	Cl_7	Cl_8	Cl_9	Cl_{10}	Σ	Mirex	heptachlor epoxide	α-endosulphan	dieldrin	endrin	methoxychlor
EAST WHITEFISH STATION																							
733	M	4.62	100	770	190	3049	9400	5800	29	652	1671	1732	345	44	4	–	4477	43	95	<2	340	<6	<22
730	M	4.26	102	790	220	2539	9100	5700	30	640	1891	2270	592	91	8	2	5524	21	130	<3	510	13	<30
726	M	4.11	91	640	235	1733	4300	3400	14	509	1214	1307	132	22	2	–	3200	29	78	<1	250	<3	<12
			98	640	241	1331	4200	3300	14	520	1316	1308	280	35	0.4		3473	30	72	<1	220	<4	<15
725	M	4.29	102	640	194	1243	4200	3100	23	457	1082	1191	254	31	–	–	3038	30	55	<1	210	<4	<15
743	M	3.76	82	570	430	1226	4000	3100	20	434	1166	1455	338	44	–	–	3457	38	65	<2	140	6	<12
744	F	3.45	89	320	149	240	350	1300	25	142	229	177	35	3	–	–	611	9	7	<5	86	4	<12
745	M	4.72	81	920	153	1580	5200	7100	41	936	2319	2003	357	44	–	–	5700	37	20	<5	310	<8	<26
736	M	4.14	86	800	160	2140	8500	6700	26	678	2174	2539	605	86	8	–	6116	53	68	<1	250	<12	<40
739	M	3.86	77	630	220	930	2500	2700	22	454	1059	1032	164	19	–	–	2750	21	57	<1	120	8	<9
KENDALL ISLAND																							
729	F	3.76	102	790	185	1254	5300	4000	11	640	1632	1729	394	54	5	1	4466	35	76	<2	280	<6	<23
710	M	4.39	96	460	280	926	1410	2000	19	263	593	650	168	27	–	–	1720	24	58	<1	200	<4	<16
715	M	4.42	100	65	103	168	148	920	9	57	91	81	18	–	–	–	256	4	10	<1	45	4	23
741	M	4.54	78	840	170	1450	6000	4300	26	586	1600	1959	419	57	–	–	2883	38	88	<6	250	11	<34
742	M	4.38	82	650	480	1000	2600	2800	24	431	993	1008	184	20	–	–	2660	21	66	<1	140	8	<11
			84 ± 25	626 ± 233	227 ± 106	1373 ± 792	4496 ± 3016	3776 ± 1929	22 ± 8	492 ± 229	1269 ± 668	1363 ± 711	291 ± 179	42 ± 25	5 ± 3	1.5 ± 0.7	3357 ± 1783	29 ± 13	62 ± 33		223 ± 119		
BEAUFORT SEA 1983-1987				650 ± 150	230 ± 60		2200 ± 830	3830 ± 1160	60 ± 30	690 ± 210	970 ± 270	1050 ± 260	460 ± 110	80 ± 30	6 ± 3		3330 ± 2320	40 ± 10			230 ± 50		

CIRCUMPOLAR SURVEY OF PCBs IN BELUGA

PROGRAM LEADER: D. Muir, Fisheries and Oceans Canada

PROJECT TEAM: D. Muir, B. Grift, C. Ford, M. Segstro (contractor)

OBJECTIVES:

1. Determine temporal and spatial trends in PCBs and other organochlorines in arctic beluga whales and other marine mammals on a circumpolar basis.

2. Provide data for use in surveys of dietary contamination by circumpolar countries.

DESCRIPTION:

As top predators in marine food chains, belugas (*Delphinapterus leucas*) are an excellent species for studying the presence and geographic variation of lipophilic organochlorine chemicals such as polychlorinated biphenyls (PCBs) and chlorinated pesticides. The beluga are also important to native peoples in arctic coastal communities of Canada, Greenland and Alaska who consume marine mammals as part of their traditional diets.

Previous work by our lab showed that blubber samples from the five Canadian arctic beluga stocks (Beaufort Sea, High Arctic, Cumberland Sound, East and West Hudson Bay) have very similar levels of PCBs and other organochlorines in blubber suggesting rather uniform contamination of arctic marine food chains (Muir *et al.* 1990). There is little information on contaminant levels in other circumpolar beluga populations.

The general objective is to determine levels of PCBs and other organochlorine contaminants in tissues of belugas from at least 4 distinct beluga stocks: (1) Western Greenland, (2) S. Beaufort/Chukchi Sea stock, (3) N. Bering Sea/Norton Sound and (4) Western Soviet Arctic, in order to describe the circumpolar variation in levels of contaminants in arctic food chains. A second important objective and outcome of the work is the promotion of scientific exchange of samples and methodology among circumpolar countries.

The specific objectives for 1991-92 were to determine PCBs and organochlorine pesticide residues in samples of beluga blubber from western Greenland animals (in collaboration with Dr. Mads-Peter Heide-Jørgensen, Greenland Fisheries Research Institute, Copenhagen), to compare levels with animals in Canadian waters, and to examine variation in contaminant levels with age and sex.

ACTIVITIES IN 1991/92:

(a) **Samples:** A total of 140 beluga blubber samples from two locations in western Greenland waters (the Nuussuaq area (approximately 74°N,58°W) and the Sassat/Saqqaq (Disko Bay) area (approximately 69°N, 85°W) were analyzed for PCB congeners and organochlorine pesticides (hexachlorocyclohexanes (HCH), toxaphene (PCCs), chlordane, and the DDT group).

(b) **Methods:** The extraction and separation of analytes from lipid coextractives were the same as those described in Muir *et al.* (1990). Blubber extracts were chromatographed on a 60m x 0.25 mm DB-5 column with H_2 carrier gas using a Varian 6000 GC with an ^{63}Ni electron-capture detector and Model 651 data system using GC conditions described in previous studies (Muir *et al.* 1988). Total PCB (ΣPCB) was the sum of all congeners. Total chlordane (ΣCHLOR) was the sum of all chlordane-related compounds including heptachlor epoxide while total DDT (ΣDDT) was the sum of 4,4'- and 2,4'-DDE, -DDD, -DDT isomers. Polychlorinated camphenes (PCCs) were quantified after first obtaining response factors for individual PCC peaks from the weight percent of each peak in the total ion chromatogram (Electron impact GC-mass spectrometry) of a toxaphene standard. Total PCCs was the sum of the areas of 19 peaks (8 major peaks were generally observed) (Muir *et al.* 1992a).

(c) **Quality assurance:** Internal standard recoveries (aldrin and octachloro-naphthalene) were uniformly greater than 90%. A Cod liver standard reference material (SRM-1588) from National Institute of Standards and Technology (Gaithersburg, Va) was analyzed for major organochlorine pesticides and PCB congeners. During the period over which the beluga blubber were analyzed the laboratory took part in an ICES (International Council for Exploration of the Sea) interlaboratory comparison of PCB congeners in seal blubber.

RESULTS:

The major organochlorine contaminants in all beluga blubber samples were PCBs, PCCs, ΣDDT (mainly 4,4'-DDE) and ΣCHLOR (mainly *trans*-nonachlor and oxychlordane) (Table 1). Hexachloro-cyclohexanes (ΣHCH), chloro-benzenes (ΣCBZ; tetra-, penta- and hexachloro-isomers) and dieldrin were present at lower concentrations than the 4 major organochlorine groups. Concentrations of ΣDDT and ΣPCB were lower in females than in males, as is generally observed in cetaceans and pinnipeds (Aguilar 1987).

The Nuussuaq group includes some of the highest and lowest results of ΣPCB levels observed so far in beluga from Greenland and from the Canadian Arctic, ranging from 15,550 ng/g in a young male (5 yrs) to 470 ng/g in a 10 yr old female. Mean concentrations of all major organochlorine groups (ΣPCB, ΣDDT, ΣCHLOR, PCC) were not significantly different between the Nuussuaq and Sassat/Saqqaq groups, for males or for females (using the Student's t-test at 95% level of probability). Coefficients of variation were high, ranging from 13% to 80% for ΣPCB due to the influence of age.

Highest concentrations of ΣPCBs and ΣDDT in blubber were generally found in older males but there was remarkably little difference between levels in juvenile males and those >10 years of age. There were no significant correlations between age and ΣPCB or ΣDDT concentrations. Mean PCC concentrations appeared to decline with age although the correlation with age was not statistically significant. Females showed a consistent decline in concentrations of ΣPCB, ΣDDT and PCCs with age especially for those older than 5-6 years which are probably reproductively active, but this decline did not fit a simple linear expression of concentration versus age (or log concentrations vs age). High mean levels of ΣPCBs, ΣDDT and PCCs are seen in the blubber of young animals (0-1.5 yrs group). This is due to the transfer of contaminants in the mother's milk. Great variability was observed in organochlorine concentrations in the juveniles which may be due to the number of previous parturitions by the mother. Calves from first parturitions are expected to receive greater exposure via milk compared with those born subsequently because the mother will have maximum concentrations of organochlorines in blubber (Tanabe *et al.* 1987)

ΣDDT was weakly positively correlated with age in Hudson Bay males (Muir *et al.* 1990) and positive correlations with age were also observed in male beluga from the St. Lawrence estuary (Martineau *et al.* 1987; Muir *et al.* 1990). However, these correlations were obtained with a limited number of age classes, and generally with older animals. The Greenland beluga data is much larger and more representative of the population. Further analysis of the data excluding juveniles from first parturitions might be useful to clarify the age versus concentration relationship.

Mean concentrations of ΣPCB and ΣDDT in males from Nuussuaq were significantly higher than in males from Jones Sound and East Hudson Bay (Student's t-test at $p < 0.01$) but did not differ statistically from levels of these compounds in the Cumberland Sound animals (Table 1). There were also significant differences between Nuussuaq females and those from Cumberland Sound and East Hudson Bay but age differences probably account for this. The latter animals were older on average than the Nuussuaq group. Levels of PCC and ΣCHLOR in the Nuussuaq males were not significantly higher than levels in males from Jones Sound or East Hudson Bay. The White Sea sample (3 samples were received but they appeared to be from one animal) had much higher levels of all contaminants than the Greenland and Canadian arctic animals (Table 1).

Table 1. Concentrations (arithmetic means ± standard deviations) of major organochlorines in blubber of belugas from Canadian and Greenland waters (ng/g wet wt).

Location	Sex	Age (yrs)	N	ΣCHLOR	ΣDDT	ΣPCB	PCC
Nuussuaq	M	4.8 ± 5.1	54	2600 ± 1160	4370 ± 2730	5580 ± 2500	3930 ± 1550
	F	5.9 ± 4.5	61	1920 ± 1100	2880 ± 1930	4010 ± 2300	3190 ± 1610
Sassat/	M	6.9 ± 3.7	10	1790 ± 346	2890 ± 570	4720 ± 932	2980 ± 684
Saqqaq	F	8.3 ± 3.9	13	1070 ± 689	1860 ± 1816	2710 ± 2150	1960 ± 1060
Jones Sound	M	4.4 ± 2.2	8	1870 ± 440	1960 ± 320	2530 ± 570	4250 ± 1020
	F	4.6 ± 2.9	7	1840 ± 1130	2190 ± 1690	2460 ± 1980	3740 ± 2120
Cumberland	M	7.3 ± 6.5	6	2380 ± 400	6830 ± 1890	4910 ± 250	5780 ± 5390
Sound	F	8.1 ± 7.3	6	620 ± 150	400 ± 280	1150 ± 410	1770 ± 1760
White Sea	?	-	3	4841 ± 338	63910 ± 3690	37320 ± 3960	9580 ± 1630

CONCLUSIONS AND UTILIZATION OF RESULTS:

The results represent the first detailed analysis of the variation of organochlorine levels in beluga blubber with age and sex. They demonstrate that highest levels of PCBs and other contaminants are found in juvenile animals, and in males of all ages, and the lowest in older females. This information will be of value in assessing dietary intake of the contaminants. The results indicate that spatial trends in contaminant levels can only be assessed if sufficient samples from the same age class and sex are included.

It appears that West Greenland belugas resemble the Cumberland Sound group in terms of mean organochlorine concentrations, confirming previous results that indicated male belugas from Cumberland Sound and narwhals from the northern Baffin Island area had significantly higher ΣPCB and ΣDDT than Hudson Bay belugas (Muir *et al.* 1992). Differences in dietary exposure to organochlorines may exist between whales inhabiting the Davis Strait/Baffin Bay area compared to those inhabiting shallower waters of Hudson Bay and Hudson strait. Greenland halibut, a bottom and pelagic feeding predator, is widely distributed from the Gulf of St. Lawrence to Baffin Bay but is not found in the shallower waters of Hudson Strait. A diet higher in predacious deep water fish such as halibut may explain the higher concentrations in the West Greenland and Baffin stocks relative to those of Hudson Bay but this needs to be confirmed by investigating contamination in lower trophic levels of the marine web in the region.

Further studies are planned for 1992/93 to (1) investigate levels of organochlorines in mattak and kidney which will more directly address the question of contamination of traditional diets, and (2) further analyze the results described above for blubber to examine levels in

juveniles from first parturitions in order to clarify the age versus concentration relationship. (3) Also planned for 1992/93 is completion of the isolation of individual PCC components from beluga blubber in order to identify them and develop a better method of quantifying toxaphene. Future plans include analysis of Alaskan beluga samples and development of additional contacts with Russian scientists so that samples will be forthcoming from the Russian Arctic. Finally, in the mid-1990's temporal trends in contaminants in Canadian beluga stocks will need to be assessed because previous analyses were on samples from the 1983-87 period.

Expected project completion date: March 31, 1997.

Partners: Inuit Circumpolar Conference (Nuuk, Greenland), Greenland Fisheries Research Institute, NOAA (Anchorage, Alaska), National Institute of Standards and Technology (Gaithersburg Va), Collaboration with Murmansk Institute of Marine Biology and other Russian scientists.

RESOURCES: (received in 1991/92, 1992/93 and planned under Green Plan AES)[1,2]

	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
$K	20	25	25	20	20	20

[1] This project will be combined with B.3.1.1. "Spatial trends in organochlorines in seals and walrus" for 92/93 and following years.

[2] DFO provides capital equipment and PYs. ICC (Greenland) provided 25K during 1992/92 and will provide $10K during 1992/93 for analysis of samples collected by Greenland Fisheries Research Institute.

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CO-PLANAR PCBS IN ARCTIC MARINE MAMMALS AND FISH

PROGRAM LEADER: D. Muir, Fisheries and Oceans Canada

PROJECT TEAM: D. Muir, C. Ford, and B. Grift (Fisheries and Oceans Canada, Central and Arctic Region, Winnipeg)

OBJECTIVES:

1. Provide geographic and temporal information on toxic PCB congeners.
2. Compare arctic results with mid-latitude levels of co-planar PCBs.
3. Provide a linkage to biomarker studies in the same fish and marine mammals and do surveys of dietary contamination.

DESCRIPTION:

PCB congeners with 3,4,3',4'-chlorine substitution are the most biologically active and are referred to as toxic "co-planar" or "non-ortho" PCBs. They lack chlorine substituents in the 2 and 6 (or ortho) positions and can therefore assume a planar configuration. These congeners are isostereomers of 2,3,7,8-TCDD and have similar mode of action; induction of hepatic mixed function oxidase (MFO) enzymes, immunotoxicity, teratogenicity and embryotoxicity (Safe 1990). The toxicity of Aroclor mixtures (commercial PCB formulations) is thought to be due almost entirely to these co-planar PCBs (Kannan *et al.* 1988).

Another group having a single chlorine in the 2- position is referred to as "mono-ortho" PCBs. Some of these compounds also have MFO enz[illegible] induction potencies which are similar to those of the co-pla[illegible] molecules. Toxic equivalent factors (TEFs) of mono-ortho and non-ortho congeners, which are a measure of the biological potency relative to 2,3,7,8-TCDD, range from 0.1 for PCB-126 (3,3',4,4',5-pentachlorobiphenyl) to 0.01 for PCB-77 (3,3',4,4'-tetrachlorobiphenyl) (Safe 1990). Mono-ortho PCBs have been assigned TEFs of 0.001 (Safe 1990). These TEFs were used to calculate the contribution of co-planar PCBs to total toxic equivalents in arctic tissue samples.

Preliminary studies of diet samples from Broughton Island showed that co-planar PCBs were present in fatty tissues of ringed seal, walrus, narwhal and polar bear as well as arctic char (Muir and Ford, 1990). The results showed that co-planar PCBs account for most of the "TCDD equivalents" in arctic diet samples. The objectives of this work for 1990/91 were to broaden the survey of co-planar PCBs to a larger number of tissues, especially fish tissues. This information is needed to evaluate current risks of exposure to the toxic PCBs for human consumers and to support the biomarker studies on marine mammals and fish which will assess responses at the biochemical level to PCBs and dioxins/furans.

ACTIVITIES IN 1991/92:

Non-ortho and mono-ortho substituted PCBs were determined in 13 beluga blubber samples from the Tuktoyaktuk area (Husky Lake), and in 26 arctic char samples from Somerset Island, Pond Inlet, and Spence Bay in N.W.T. and in 6 arctic char from George River (Kangiqsualujjuaq) and Salluit in the Ungava region of Northern Québec. The method of analysis is described in more detail by Muir and Ford (1990). In brief, fish tissues were extracted with hexane:dichloromethane (1:1), and lipid was removed with automated gel permeation chromatography. In most cases the sample extract was split into two portions, one for determination of non-ortho PCBs and the other for determination of all other organochlorines. Samples for determination of non-ortho PCBs were chromatographed on a silica-gel column to remove additional lipid coextractives then subjected to carbon-column chromatography to isolate the planar PCBs. The carbon column elutes were then analyzed by GC-MS analysis and non-ortho PCBs quantified with the aid of ^{13}C-internal standards for PCB-77, 126 and 169 (3,3',4,4',5,5'-hexachlorobiphenyl). Mono-ortho PCBs (congeners 105, 118, 114, 156) were determined by GC-ECD following chromatography on a Florisil column to separate PCBs from most organochlorine pesticides. Pooled samples of char from the three sites in N.W.T., and the beluga whale blubber, were also analyzed for chlorinated dioxins/furans (PCDD/PCDFs) by DFO's Ultratrace laboratory in Burlington, Ontario.

Our lab also participated in an international interlaboratory comparison of non-ortho PCBs in marine mammal fat coordinated by the Swedish Environmental Protection Agency (De Wit 1992).

RESULTS:

(a) **Beluga whales:** Concentrations of the non-ortho PCBs, 77 and 126, in beluga whale blubber from the Beaufort Sea were similar to levels we have reported previously for belugas and narwhal from Baffin Bay (Table 1). Levels of PCB 169 were higher than reported previously by a factor of 6-times in the case of male beluga. The reason for these elevated levels of PCB 169 is not known. However one possible explanation is that PCB 169 is less rapidly mobilized, compared to lower molecular weight PCBs, as the animals utilized their blubber fats when they were trapped in ice in the winter of 1989-90. In support of this hypothesis hexa- and heptachlorobiphenyls made up 34% and 11% of ΣPCB, respectively, in these animals versus an average of 24 and 12% in Cumberland Sound belugas. In terms of percent of ΣPCB the results were consistent with previous observations that the proportion of PCB 77 and 126 in beluga and narwhal is lower than in ringed seals and fish.

PCDD/F's were determined in one pooled sample of beluga blubber (combined males and females) from the Husky Lake. The concentration of 2,3,7,8-TCDF was 1.0 ng/kg while 2,3,7,8-TCDD was undetectable <1 ng/kg. Other (unidentified) TCDD congeners were detected totalling 6 ng/kg. These results confirm previous studies which suggest that beluga have a high degradative capacity for PCDD/F's (Norstrom *et al.* 1990).

(b) **Arctic char:** Low ng/kg concentrations of PCB 77, 126 and 169 were found in arctic char (whole fish) collected from the commercial char fisheries on Somerset Island, at Spence Bay and at Pond Inlet, and in char from northern Québec (Table 1). PCB 77 was the predominate congener in char tissue representing 0.02 to 0.07% of ΣPCB. Although PCB 126 was near detection limits in char it also represented a relatively high proportion of ΣPCB (Table 1). Thus, in general, the proportion of non-ortho PCBs to ΣPCBs in fish is higher than in marine mammals. Similar results were observed by Asplund *et al.* (1989) in fish and seal tissues from the Baltic Sea. Fish had higher levels of co-planar PCBs than ringed seal blubber although ΣPCB in the blubber was much higher than in fish.

Low levels of 2,3,7,8-TCDD and -TCDF in char tissue were detected in arctic char from Somerset Island (1 ng/kg TCDF and 2 ng/kg TCDD) and undetectable in pooled samples from the other two locations. All 3 samples contained low levels (3 to 9 ng/kg) of unidentified tetrachlorodioxin congeners which were not quantified.

(c) **Interlab study:** This laboratory performed relatively well in the Swedish interlab study coming within about 10% of the concensus value in two of three samples. However, we were off by about 50% in the third sample. The results indicated some problems in our lab with linearity of response for the relatively large coplanar PCB peaks encountered in these samples. These were corrected prior to analysis of the char and beluga samples.

(d) **TCDD equivalents:** To assess the relative importance of non-ortho and mono-ortho PCB congeners, as well as TCDD and TCDF, TCDD equivalent concentrations (TECs) were calculated by multiplying by published Toxic Equivalent Factors (TEF) for each congener (Safe 1990). TEF values for mono-ortho PCBs 118, 114 and 156 of $1x10^{-4}$, $2.5x10^{-5}$ and 1.0×10^{-4}, were taken from Smith *et al.* (1990). TECs in arctic char which are contributed by PCB congeners range from 1.0 to 2.2 among the five locations (levels for 2 northern Québec sites were assumed to be the same as mean levels from the three central arctic locations). Thus TCDD/F at concentrations of 1 pg/g contribute 45 to 55% of TECs (Fig. 1). In beluga, the mono-ortho PCBs 105 and 118, along with PCB 126, account for the major proportion of TECs while chlorinated dioxins/furans make a negligible contribution (Fig.1)

CONCLUSIONS AND UTILIZATION OF RESULTS:

The results indicate that non-ortho and mono-ortho PCBs contribute a substantial proportion of TECs in arctic marine mammal and fish samples. Levels in the sea run char were the lowest observed so far. Somewhat higher levels of mono-ortho PCBs were found in samples of arctic char from Broughton Island (Ford and Muir 1990) and in samples from northern Québec. Ages of the fish, sex and time of year (spawning) may affect levels of the PCB congeners. Thus further study of char is needed to sort out these variables. Additional work is also needed on landlocked char, which we have found (Project B.4.) to have higher levels of PCBs than sea run animals. Other marine mammals with high levels of PCBs, for e.g. walrus, have not previously been

investigated for levels of non-ortho congeners or dioxin/furans.

Plans for 1992/93 and subsequent years are to broaden the limited database by determining non-ortho PCBs in additional marine and freshwater fish and in whale and seal tissues to develop a larger database than is available at present. The project will also provide support for biomarker studies in fish and marine mammals and will forward results to Health and Welfare for assessment of dietary contamination.

Expected project completion date: March 31, 1997.

Partners: CWS (Hull) has provided advice on analytical methodology. The results are supplied to NH&W for evaluation of health risk.

RESOURCES: (received in 1990/91, 1991/92, 1992/93 and planned under Green Plan AES)

	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
$K	24	36	24	30	30	30	18

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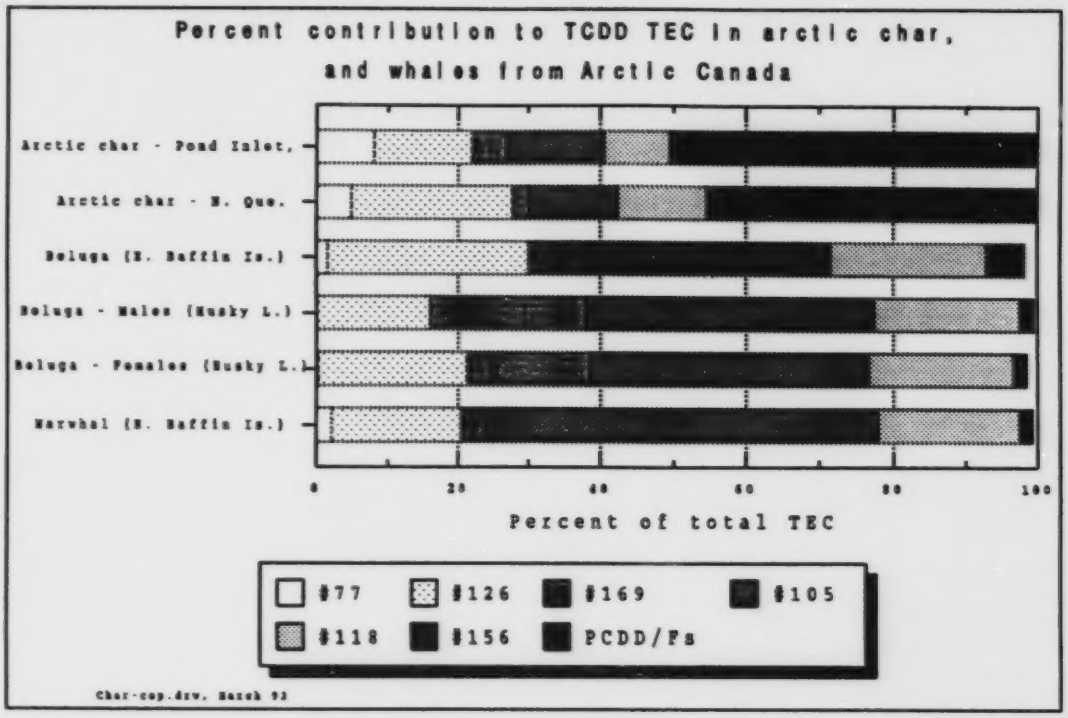
Table 1. Mean concentrations of non-ortho PCB congeners and percent of ΣPCB in beluga from Husky Lakes (near Tuktoyaktuk) and in Arctic char from the Central Arctic and Northern Québec.

Species	Sex	N	Concentration (ng/kg wet wt)			Percent of ΣPCB		
			77	126	169	77	126	169
A. Marine mammal blubber								
Beluga (Husky L.)	F	5	82±45	80±37	131±52	0.005	0.005	0.009
	M	8	120±57	212±85	588±385	0.005	0.004	0.012
Beluga (Baffin Bay)	M	6	105±106	201±127	97±29	0.002	0.004	0.002
Narwhal (Baffin Bay)	F	6	128±70	93±68	42±30	0.005	0.004	0.002
	M	16	199±196	187±99	52±23	0.004	0.003	0.001
Ringed seal (Broughton Is.)	M+F	4[1]	86±45	94±37	17±18	0.014	0.016	0.003
B. Arctic char whole fish								
Somerset Is.	F	4	6±5	1±1	<1	0.033	0.006	<0.005
	M	4	13±6	3±1	2±1	0.073	0.017	0.010
Pond Inlet	F	5	6±3	2±1	2±4	0.050	0.017	0.017
	M	5	6±6	1±1	<1	0.050	0.009	<0.005
Spence Bay	F	5	4±5	1±1	1±1	0.021	0.005	0.005
	M	4	10±7	3±3	1±2	0.060	0.018	0.006
Salluit	M+F	2	26	9	<1	0.075	0.026	<0.003
Kangiqsual-ujjuaq	M	4	25±18	13±7	<1	0.040	0.021	<0.002

[1] 4 pooled samples consisting of 2 pooled extracts.

Fig. 1. Percent of PCBs and dioxin/furans contribution to TCDD TEC in char, beluga and narwhal.



LEVELS OF CONTAMINANTS IN FISH FROM YUKON LAKES

PROGRAM LEADER: Mark Palmer

PROJECT TEAM: Yukon Technical Committee on Northern Ecosystems and Native Diets

OBJECTIVES:

1. To collect information to complement that gathered in the 1991 season by sampling additional lakes throughout the Yukon.

2. To collect information to confirm that gathered in the 1991 season to address concerns raised by health advisories based on existing data.

3. To determine spatial variability in contaminant loadings, and to assess short term trends.

4. To investigate the sources, processes and rates of contaminant deposition and transport into and within the waters of the Yukon.

5. To determine levels of contaminants for use in long term trend analysis.

6. To develop additional monitoring on levels of organic contaminants within the Yukon.

7. To provide additional information for use in updating health advisories.

RATIONALE:

Recent burbot liver and lake trout flesh samples from headwater lakes in the Yukon River system (Tagish, Laberge, etc.) indicate elevated levels of organochlorine pesticides. In response to elevated toxaphene levels, Health and Welfare Canada issued a public health advisory on Lake Laberge. This recommended that consumption of lake trout flesh be limited, and that burbot livers not be consumed. This has affected the various fisheries on the lake, and generated considerable concern from residents who have used the fisheries resources of the lake.

There is as yet insufficient information to determine the source(s) of the contamination. Additional information is essential to understand the current situation, and to use that understanding to determine the source(s) of the contamination. Knowledge of the background levels in the water bodies supporting fisheries is also required to address public health concerns with the various fisheries.

ACTIVITIES/RESULTS:

A total of 8 southern Yukon lakes were sampled as part of the 1991/92 fish sampling program. The lakes and species collected are outlined in the attached tables. All samples were collected between August and December, 1991.

In order to reduce costs, only selected samples were sent for analysis with the remainder being archived for future testing. As a result of Health and Welfare Canada issuing an advisory on the first set of data, limiting the amount of Atlin Lake burbot an individual could consume, samples from all lakes were sent for analysis.

All results generated under last year's program were assessed by Health and Welfare Canada. No additional advisories were released. All of the data is summarized in the attached tables.

FUTURE WORK:

Only a small number of fish from selected southern Yukon lakes have been tested for organochlorines. As a result of the two health advisories already in effect (Lake Laberge burbot and lake trout, 1991 and Atlin Lake burbot, 1992), it is imperative that additional lakes throughout the Yukon be tested for health assessment purposes and for use in determining the source and transport of organochlorines in the Yukon.

RESOURCES: (received in 1991/92, 1992/93 and planned under Green Plan AES)

	1991/92	1992/93	1993/94	1994/95
$K	147	56	105	51

YUKON TROUT MUSCLE DATA
1991/92 AES FISH SAMPLING PROGRAM

LOCATION	N	# FISH	LIPID %	TOXAPHENE (ppb)	PCB'S (ppb)	sDDT (ppb)	sCHLOROBENZENES (ppb)	sHCH (ppb)	sCHLORDANE (ppb)
Atlin Lake	15	15	1.72	124 (44-210)	12.6 (4.8-32.0)	6.9 (1.9-17.2)	1.0 (0.2-1.8)	1.9 (0.2-4.7)	9.6 (2.9-20.9)
Bennett Lake	10	66	1.93	304 (11-720)	67.7 (3.1-370.0)	38.7 (1.6-180.0)	2.2 (.2-4.7)	2.9 (ND-4.0)	25.2 (0.7-74.5)
Kluane Lake	3	8	3.60	19 (7-33)	13.8 (2.7-29.0)	8.5 (0.9-17.0)	1.6 (1.0-2.4)	1.7 (1.0-2.4)	3.0 (1.2-5.3)
Marsh Lake	3	15	3.37	106 (89-120)	8.6 (6.2-11.6)	9.8 (4.4-19.0)	1.0 (0.8-1.3)	2.8 (1.4-4.6)	6.6 (5.1-7.4)
Tagish Lake	12	73	2.16	238 (22-650)	33.0 (3.7-173.0)	44.0 (1.2-360.0)	1.7 (0.3-4.7)	2.8 (0.8-10.6)	16.3 (1.6-68.5)
Teslin Lake	3	9	7.05	59 (35-89)	23.0 (11.8-43.5)	15.7 (7.6-31.0)	2.8 (2.6-3.3)	0.6 (ND-0.5)	7.3 (4.9-12.0)

s represents total
Value in brackets is the range of results
Results are expressed as wet weight basis
ND values are not used in calculating the means

YUKON BURBOT LIVER DATA
1991/92 AES FISH SAMPLING PROGRAM

LOCATION	N	# FISH	LIPID %	TOXAPHENE (ppb)	PCB'S (ppb)	sDDT (ppb)	sCHLOROBENZENES (ppb)	sHCH (ppb)	sCHLORDANE (ppb)
Atlin Lake	6	20	33.1	1533 (1200-2100)	135 (102-170)	105 (47-149)	17.0 (15-22)	63.0 (55-79)	137.5 (14-24)
Fox Lake	6	17	27.6	54 (27-100)	52 (25-119)	126 (50-400)	6.4 (4.3-11)	18.0 (10-33)	11.7 (0.5-2.1)
Kluane Lake	2	6	35.1	54	50	43	7.8	2.1	9.9
Schwatka Lake	3	11	15.3	272 (190-370)	104 (74-120)	282 (210-350)	4.5 (3.7-5.8)	10.4 (8.0-13.0)	20.0 (15.7-25.2)
Teslin Lake	3	7	40.3	267 (240-310)	175 (164-194)	114 (93-150)	16.7 (16.0-17.0)	6.3 (4.9-7.4)	50.9 (42.8-59.9)

s represents total
Value in brackets is the range of results
Results are expressed as wet weight basis
ND values are not used in calculating the means

YUKON WHITEFISH MUSCLE DATA
1991/92 AES FISH SAMPLING PROGRAM

LOCATION	N	# FISH	LIPID %	TOXAPHENE (ppb)	PCB'S (ppb)	sDDT (ppb)	sCHLOROBENZENES (ppb)	sHCH (ppb)	sCHLORDANE (ppb)
Atlin Lake	2	5	0.25	6.0	0.1	0.5	0.1	0.2	0.3
Bennett Lake	3	10	2.08	26.0 (19.0-39.0)	2.7 (1.0-3.6)	2.3 (1.0-3.2)	0.7 (0.5-1.1)	0.8 (0.4-1.7)	1.3 (0.6-1.8)
Kluane Lake	3	12	1.80	7.0 (ND-9.0)	3.5 (2.6-5.4)	1.8 (1.4-2.2)	0.9 (0.8-1.0)	1.0 (0.7-1.4)	1.0 (09.-1.1)
Marsh Lake	5	32	0.76	29.9 (ND-79.0)	2.0 (ND-6.3)	5.8 (0.9-12.4)	0.5 (0.2-1.2)	1.7 (ND-2.6)	1.2 (ND-2.7)
Tagish Lake	1	4	0.90	30.0	3.4	1.5	0.6	0.6	2.2

s represents total
Value in brackets is the range of results
Results are expressed as wet weight basis
ND values are not used in calculating the means

CONTAMINANT TRENDS IN FRESHWATER BIOTA

PROGRAM LEADERS: D. Muir and W.L. Lockhart, Fisheries and Oceans Canada, Central and Arctic Region

PROJECT TEAM: D. Muir, B. Grift, D. Metner, B. Billeck, W.L. Lockhart, B. Rosenberg (contractor)

OBJECTIVES:

1. Determine temporal and spatial trends in PCBs, other organochlorines and PAHs in fish from lakes and rivers in NWT and N. Quebec.

2. Provide information on contaminants to evaluate current risks of exposure to PCBs, PAHs and chlorophenols via fish consumption.

DESCRIPTION:

Reviews of contaminant data in freshwater fish from arctic and subarctic Canada (Lockhart *et al.* 1992; Muir *et al.* 1990) indicate that information on the levels and geographic variation of PCBs and related organochlorines (OCs) and polyaromatic hydrocarbons (PAHs) is limited while data on temporal trends is nonexistent. The initial objectives of the project (1989-91) were to determine organic contaminant levels in fishes from remote lakes in northern Québec and N.W.T., first monitored in 1970 by Reinke *et al.* (1972) and Riseborough and Berger (1971), in order to examine the general temporal trends in DDT, dieldrin and PCBs as well as investigate the presence of additional contaminants not reported in the early work. In addition, comparison of contaminant levels in fishes from remote lakes in southern Canada with those in similar size lakes in the Arctic will be made to provide further perspective on the extent of contamination. Although the main focus of the study is on piscivorous fishes, (such as burbot, lake trout and arctic char) because of interest in biomagnification of PCBs, DDT-compounds and other OC pesticides, there is also a need to examine contamination of fishes feeding at lower trophic levels, such as whitefish, which are also of dietary importance to native people in NWT and the Yukon and N. Québec.

ACTIVITIES IN 1991/92:

(a) **Fish samples:** Broad whitefish (*Coregonus nasus*) were obtained from Canyanek Creek on the Tuktoyaktuk peninsula, and lake whitefish (*Coregonus clupeaformis*) from Fisherman Lake, south of Fort Simpson, N.W.T. Landlocked arctic char (*Salvelinus alpinus*) were obtained from Lake Hazen (82°N) on Ellesmere Island, during sampling expeditions for lake sediments. Sea run arctic char (N=28) were obtained from commercial fisheries at Spence Bay, Pond Inlet and Somerset Island. Sex and age (using ootoliths) of fish were determined. In addition to the above samples, arctic char were obtained from Buchanan Lake on

Axel Heiberg Island and walleye, lake trout and burbot from Trout Lake (near Fort Simpson) by DFO personnel in Yellowknife.

(b) **Analysis:** Samples of whole fish or muscle were analyzed for PCB congeners and other organochlorine contaminants (toxaphene (PCCs), chlordane (CHLOR), and the DDT group). Methods of extraction and GC analysis were identical to those described by Muir *et al.* (1990). Where possible, fishes of known age, sex and size class were selected. A limited number of samples were set aside for analysis of non-ortho substituted PCBs and chlorinated dioxins/furans (see report on project C.1.2).

(c) **Quality Assurance:** Internal standards of aldrin and octachloronaphthalene were added to all samples. Blank samples were run approximately every 10 samples to check contamination of reagents and glassware. To check precision of the analysis of PCBs in arctic char about 1/3 of the samples were analyzed in duplicate. During 1991 the laboratory participated in the ICES interlab comparison program and a CAPCO fish check samples program for analysis of PCB congeners. A NIST cod liver oil reference material was analyzed along with the fish samples.

RESULTS:

All major classes of organochlorine contaminants (PCBs, chlorobenzenes, OC pesticides) were detectable in whitefish muscle at low part per billion levels. PCCs were the major organochlorine contaminants averaging 6.4±3.2 ng/g in the 10 samples. Concentrations of PCBs, chlordane-related compounds and hexachlorocyclohexanes (ΣHCH) were similar, averaging 2.2, 1.7, and 1.9 ng/g (wet wt), respectively in the ten samples. Wet weight concentrations of PCC, ΣPCBs, ΣHCH and ΣCHLOR were higher in males than in females, however, means were not significantly different (t-test at $P < 0.05$). The slightly higher levels may be related to lipid content, which was higher in males than females. Males were also older (maturity = 7) than females (maturity = 1-2). On a lipid weight basis the differences were reversed with slightly higher levels of PCC, ΣPCBs, and ΣCHLOR in females, although differences were not statistically significant ($P < 0.05$) (Table 1). Comparisons with other locations and fish species are best done with lipid normalized results to reduce variation. Canyanek Creek whitefish had the lower levels than lake whitefish from Fisherman Lake, a remote lake south of Fort Simpson (N.W.T.) (Table 1).

Arctic char (whole fish) from Somerset Island, Pond Inlet and Spence Bay had relatively low levels of PCBs, PCCs and other organochlorines. Toxaphene (PCCs) was the major organochlorine averaging 47 ng/g wet wt in male char from Somerset Island and 27 ng/g in samples from Pond Inlet. ΣPCB in male char from Somerset and Pond Inlet averaged 17 ng/g wet wt and 11 ng/g, respectively. Levels were generally similar in male and female char from the three locations.

On a lipid weight basis levels of organochlorines in char from Somerset Island, Pond Inlet and Spence Bay were within the range observed for sea run char from three locations in the Ungava region of northern Québec (Table 1). However, levels of all organochlorines,

especially PCBs and PCCs, in landlocked char from Lake Amituk Lake on Cornwallis Island were much higher than in the sea run samples. For e.g., mean ΣPCB levels in Amituk char ranged from 7260 ng/g (lipid wt) in males to 2300 ng/g in females, 10 to 20 times higher than in sea run animals. Char from Lake Hazen also had high organochlorines, especially PCC and ΣCHLOR, relative to sea run char. Part of this difference may be due to lipid content. Fish from Amituk Lake and Hazen lake had lower lipid, averaging 3.3% and 4.6% in males, respectively, compared to 6 and 13%, in Somerset Island and Pond Inlet sea run char, respectively. Another reason for these large differences may be that the landlocked animals sampled here are piscivorous whereas the sea run animals may be eating invertebrates. Further investigation is needed to confirm these hypotheses.

CONCLUSIONS AND UTILIZATION OF RESULTS:

Sea run arctic char had similar levels of organochlorines in all locations, with PCCs and PCBs being the predominant contaminants. Concentrations of PCCs and ΣPCBs were lower by 6 to 9 times in whitefish than in sea run char when compared on a lipid basis. Based on these results, the organochlorine levels for landlocked char in Amituk Lake and Lake Hazen look very high. There is clearly more variation spatially in contaminant levels than we first expected. Food chain length and trophic status (i.e. eutrophic versus oligotrophic) of lakes also influence levels of organochlorines in fish (Rasmussen *et al.* 1990). Further analyses are required to sort out the influence of these variables on organochlorine levels in remote arctic lakes. For 1992/93 it is proposed to analyze further landlocked char to confirm the elevated levels at Amituk and Hazen Lakes. There are additional samples available from these lakes and from Buchanan Lake on Axel Heiberg Island. Further sample collections and analyses will be made on inland lakes near Yellowknife and Fort Simpson to follow up the initial work on whitefish and to broaden the database on lake trout. Additional work will focus on temporal trends in organochlorines in fish from selected locations where archived samples are available or where analyses have been done previously. The results will allow the spatial variation in PCBs and other organochlorine contaminants in the north to be assessed for the first time and provide a baseline for future assessment of temporal trends.

Expected completion date: March 31, 1997.

Partners: DFO Fish Inspection (Arctic char survey). J. Reist, K. Chang-Kue, B. Bond, DFO (Winnipeg), S. Harbicht, N. Wilson (DFO Yellowknife) provide samples. Further cooperation with NWT Renewable Resources and the Dene will be necessary to complete the sampling program.

RESOURCES EXPENDED: (received in 1991/92, 1992/93 and planned under Green Plan AES)

	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
Total ($K)	150	96	100	150	100	100

Table 1. Mean concentrations (ng/g ± SD, lipid weight basis) of major organochlorines in fish from remote Canadian lakes.

Location	Sex	N	ΣHCH	ΣCHLOR	ΣDDT	ΣPCB	PCC[1]
A. Whitefish							
Canyanek Creek	F	6	29±7	30±10	13±6	44±52	119±59
(Tuktoyaktuk)	M	4	31±10	27±11	13±9	38±6	
100±30							
Fisherman Lake (Fort Simpson)	M+F	4	70±21	43±26	31±6	672±122	190±43
B. Arctic char							
Somerset Island	F	4	59±26	173±89	97±56	400±204	725±420
	M	4	107±6	173±107	99±63	293±220	740±434
Pond Inlet	F	5	66±14	45±10	19±5	233±86	345±101
	M	5	72±8	46±8	18±6	112±28	256±43
Spence Bay	F	6	78±5	61±12	21±7	149±52	242±75
	M	4	97±8	70±57	25±22	143±54	258±233
Hazen Lake	M	6	59±7	1040±669	438±331	1650±1630	4070±2064
Amituk Lake	M	5	108±28	3540±2100	3630±2800	7260±5540	9370±5960
	F	4	137±57	1820±631	1210±523	2300±727	5700±2770
Kangiqsujuaq	F	6	17±3	84±15	40±10	223±74	344±89
(Wakeham Bay)	M	4	36±19	175±92	93±53	383±89	678±406
Kangiqsualujjuaq (George River)	M	4[2]	53±22	197±90	104±53	465±232	627±2540
Salluit	M+F	5[3]	50±6	186±49	102±41	323±113	618±287

[1] PCCs quantified using individual response factors for each GC peak.

[2] Five samples were analysed but one highly contaminanted sample (ΣPCB=2090 ng/g lipid wt) was omitted from calculation of the mean.

[3] Four males and 1 female.

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CONTAMINANT TRENDS IN POLAR BEARS

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OBJECTIVES:

1. Determine circumpolar geographical distribution of persistent organochlorine contaminants in the Polar Bear, and derive source of contamination.

2. Determine 5 year trends in contamination in the Canadian Arctic.

3. Determine exposure of polar bear fetuses and cubs to organochlorine contaminants, and assess the potential effect of these contaminants on reproduction and survival.

DESCRIPTION:

Introduction

This project is a follow up study to a survey of organochlorine contaminants and heavy metals in polar bears in the Northwest Territories which was conducted between 1982 and 1984, and a study on the distribution in tissues and the effect of age on organochlorine bioaccumulation in polar bears conducted in Hudson Bay in 1985. Species at the top of the food chain are the most contaminated. Polar bears have proven their value as geographical indicators of organochlorine contamination of the arctic marine ecosystem. Relatively high levels of PCBs and the pesticide metabolite, oxychlordane, are present in polar bears, along with lesser amounts of DDE, dieldrin, HCB and α-HCH. A number of chlordane-related compounds remain unidentified. Levels of most OCs in a sample of Hudson Bay and Baffin Bay bears were higher in 1984 than 1969, therefore it is important to establish long-term trends. It was proposed that polar bear samples from the Canadian Arctic/sub-Arctic be analyzed approximately every 5 years. Knowledge of the circumpolar distribution of contaminants is also important in determining the sources, trends and potential significance of these contaminants to arctic marine and maritime wildlife. A project for a circumpolar survey of contamination in polar bear fat was therefore agreed upon at a meeting of the

International Union on Conservation of Nature Polar Bear Specialists Group in Sochi, USSR in October, 1988. The samples were to be collected by the field biologists, and Environment Canada agreed to perform the chemical and data analyses. Most of the samples were collected between the autumn of 1989 and the winter of 1990-91. The polar bear is also a surrogate for human exposure to contaminants from ingestion of seal meat. Establishing an international monitoring program provides a means of exchanging information among circumpolar countries which can lead to a stronger Canadian influence in setting the agenda for protecting arctic animals and the people who consume them.

Activities in 1991/92

Collection of samples for the circumpolar survey of contaminants in polar bear fat was completed to the extent possible by autumn 1991. Over seven hundred samples from 24 areas/communities in Alaska, Canada, Greenland and Svalbard (Norway) were collected and analyzed. See Figure 1 for sampling sites. No samples were collected from Russia in spite of the assistance of US F&WS scientists. Use of subcutaneous biopsies obtained by 3 mm biopsy punches proved highly successful. Of the samples analyzed, 270 (42% of total) were biopsies. Of the biopsies analyzed, 179 in 1990 and 60 in 1989 were taken in western Hudson Bay as part of Ramsay's studies on fat metabolism.

The samples were analyzed for tetra-, penta- and hexachlorobenzenes; alpha- and beta-hexachlorocyclohexane; twelve chlordane-related compounds (mainly the metabolite oxychlordane); dieldrin; p,p'-DDT, DDD and DDE; and sixteen PCB congeners. All samples were analyzed by a single fraction gas chromatography-mass selective detector procedure. Quality control problems were experienced with the more volatile residues (principally chlorobenzenes and hexachlorocyclohexanes) because of the small sample sizes used. Representative subsamples from each of the major sub-population zones will therefore be reanalyzed for these residues to verify the data. In addition, PCDDs, PCDFs and non-ortho PCBs will be analyzed in these samples.

With the assistance of a contractor, a spreadsheet database has been set up. In addition to the chemical concentrations, sample identity, geographical location, and information which may be of value in analyzing the data, such as sex, age, accompanying bears, axial girth, standard length, zoological length, calculated weight, condition index, and fat index, have been added to the database where available. There are seventy potential fields of information for each sample. A three month contract (July-September, 1992) will be let to complete the preliminary statistical analysis and prepare a report. It is hoped that detailed analysis of the geographical distribution data and writeup for publication in the scientific literature can be completed by March, 1993. Because only preliminary summary statistics have been completed it is not possible to comment on the significance of temporal trends. However, a few comments can be made on geographical distribution of

residues and the effects of age and sex on residue levels.

As previously found, the major residues in all areas were PCBs and chlordane-related compounds. Figure 1 shows the distribution of the mean concentrations of total PCBs and Chlordane in the 24 designated areas. Dieldrin, hexachlorocyclohexane and chlorobenzene levels were usually an order of magnitude lower. Mean total PCB concentrations ranged from a low of approximately 2 ppm in the western North American Arctic to a high of 15-20 ppm in eastern Greenland and Svalbard. Levels in Baffin Bay and Hudson Bay areas were generally intermediate at 3-5 ppm. Thus, there appears to be a trend for levels to increase from west to east, with a substantial jump going from the Baffin Bay to the Atlantic sites. Chlordane levels were somewhat more evenly spread, ranging from 1-5 ppm in all areas, with a slight tendency for an increasing west-east trend. These data imply that most contaminants are quite evenly distributed at arctic and sub-arctic latitudes in the northern hemisphere. Asia appears to be a more important source of hexachlorocyclohexane than North America, whereas North (Central?) America is a significantly more important source of DDT to the Arctic than other areas. The significantly higher levels of PCBs in north Atlantic areas than in Hudson and Baffin Bays indicates that European, possibly Eurasian, sources are major contributors in these areas.

After grouping the data accordingly to approximate 16 zones[1] (Table 1), the data were log transformed and analyzed by zone and by area[2] (Table 2). The results of the zone analysis show that although the zones are significantly different over all 16 groups, this geographical grouping accounted for very little of the overall variability except in the cases of DDTs and PCBs. The results by area are similar, but the r^2 values are higher.

Adult males, adult females and adult females with cubs from western Hudson Bay were also compared. Chlordanes were significantly lower in males than in the two female groups, and PCBs were significantly higher in males. Virtually identical results were obtained when the two female groupings were collapsed into one and a male-female comparison was done.

[1] The term **zone** refers to the Canadian Polar Bear Management Zone. These represent geographical groups of bears which, based on current knowledge, are considered to be distinct and separate populations. The zones for bears from outside of Canada have been arbitrarily assigned for analysis purposes. The zones and their approximate locations are listed in Table 1.

[2] The term **area** refers to the village of origin of the hunter who killed the bear or the approximate area of operation for bears captured by researchers. The areas are listed in Table 2.

A wide age range was also available for the western Hudson Bay samples. There was a substantial negative effect of age from cubs to about age 6 in both sexes on PCB and chlordane residue levels in fat. Comparison of residue levels in females and their cubs showed that levels in cubs were about twice as high as those in their mothers. After age six there was no discernible age effect, indicating that the bears were in equilibrium with their diet. However, it is likely that statistical analysis will find some significant differences among groups.

FUTURE DIRECTIONS:

A new project on distribution and possible effects of methylsulfone (MSF) metabolites of PCBs and DDE was begun in 1991 as part of the Arctic Environmental Strategy Greenplan. Preliminary analysis in Sweden of fat and liver samples from two bears indicated that MSF-PCBs were present at 5% of the PCB levels in both tissues, and high levels of MSF-DDE were present in liver. These results were presented at the Special International Session on Contaminants in the Arctic, held in conjunction with the Aquatic Toxicology Workshop, which took place in Ottawa in October 1991. An analytical method for these compounds is being developed by a Ph.D. student at Carleton University in collaboration with the University of Stockholm. He will apply this method to study the distribution of MSF-PCBs and MSF-DDEs in the arctic marine ecosystem. MSF-DDE has been implicated as a possible causative agent in pathologies which are consistent with adrenal malfunction in non-reproducing populations of ringed and grey seal in the Baltic Sea in the early 1970s.

Collection and analysis of biopsies of bears taken in research programs in the Canadian Arctic, especially those which assist in establishing the effect of seasonal fat changes in determining temporal and geographic trends of organochlorines, will continue from 1992-96. It is anticipated that a number of bears will be captured several times over the course of sampling for basic physiology studies being conducted by the University of Saskatchewan.

Arctic Environmental Strategy funds will be used in 1992-93 to establish a negative ion, chemical ionization (NICI) GC-MS capability by upgrading an older mass spectrometer. NICI GC-MS is ideally suited for analysis of halogenated compounds such as chlordanes and toxaphene. The new capability will be available to other participants in arctic contaminants research, and to assist in development of a quality assurance program.

As indicated above, subsamples of previously collected material will be reanalyzed for volatile contaminants, PCDDs, PCDFs and non-ortho PCBs.

RESOURCES: (received in 1991/92, 1992/93 and planned under Green Plan AES)

	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
CWS A-base						
PY*	1.5	1.5	1.5	1.5	1.5	1.5
O&M ($K)	75	20	20	20	20	20
AES Greenplan						
O&M ($K)	75	84	90	75	75	120

* Includes 0.5 PY of AES Greenplan, 0.5 PY of Lab. Rev. Greenplan and 0.5 A-base

Sampling Sites

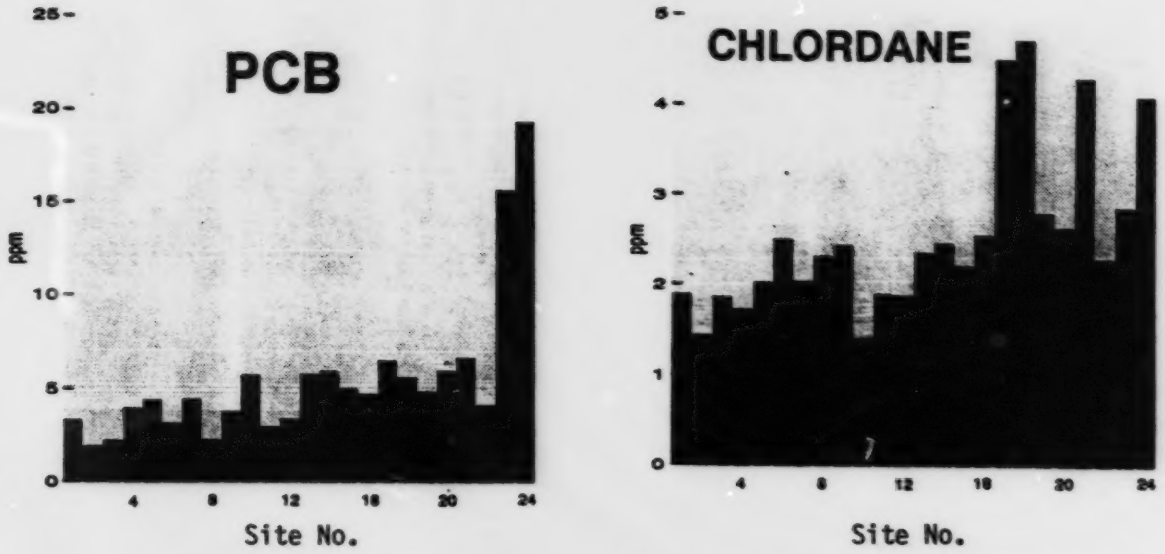

FIGURE 1: Polar bear fat sampling sites and mean levels of total PCBs (mg/kg) and total-Chlordanes (mg/kg) in lipid.

TABLE 1: ARCTIC MANAGEMENT ZONES

ZONE	APPROXIMATE GEOGRAPHICAL DESCRIPTION
A1	Western Hudson Bay
A2	Eastern Hudson Bay
B1	* Eastern Greenland (Scoresbysund)
B2	* Svalbard (Norway)
C1	Northern Hudson Bay & Foxe basin
D1	Baffin Bay
D2	Davis Strait & Labrador coast
E1	Viscount Melville Sound - McLure Strait
E2	Victoria Is. - Queen Maud Gulf - Boothia Pen.
E3	Gulf of Boothia
F1	Bathurst Island - Lancaster Sound - Ellesmere Island
H1	Beaufort Sea & Southern Amundsen Gulf
H2	Southern Arctic Ocean - Northern Amundsen Gulf incl. Banks Is., Prince Patrick Is.
J1	* Bering Sea & Strait
J2	* Chukchi Sea
J3	* Alaskan Beaufort Sea

* - These are arbitrary zone designations given to areas outside of Canada, based on the location information supplied by the American, Danish and Norwegian researchers

TABLE 2: AREAS USED IN POLAR BEAR CONTAMINANT ANALYSIS

AREA	ZONE	NAME
ARC	F1	Arctic Bay, Baffin Island
BEA	J3	Alaskan Beaufort Sea
BER	J1	Bering Sea
BRO	D1	Broughton Island, Baffin Island
CAM	E2	Cambridge Bay, Victoria Island
CHU	J2	Chukchi Sea
CLY	D1	Clyde River, Baffin Island
COP	H2	Coppermine
COR	C1	Coral Harbour, Southampton Island
DOR	C1	Dorset, Baffin Island
GRI	F1	Grise Fiord, Ellesmere Island
HAD	E1	Hadley Bay, Victoria Island
HOL	H2	Holman Island, Victoria Island
IGL	C1	Igloolik, Melville Pen.
IQA	D2	Iqualuit, Baffin Island
LHA	C1	Lake Harbour, Baffin Island
MAC	H1	Mackenzie Delta (includes Aklavik, Inuvik & Tuktoyuktuk)
MEL	E1	Melville Island
PAN	D2	Pangnirtung, Baffin Island
PAU	H1	Paulatuk

TABLE 2: AREAS USED IN POLAR BEAR CONTAMINANT ANALYSIS (Cont'd)

AREA	ZONE	NAME
PEL	E3	Pelly Bay
PON	F1	Pond Inlet, Baffin Island
REP	C1	Repulse Bay
RES	F1	Resolute, Cornwallis Island
SAC	H2	Sachs Harbour, Banks island
SAN	A2	Sanikiluaq, Belcher Islands
SCO	B1	Scoresbysund (Greenland)
SLE	A2	Sleeper Island (Belcher Islands)
SPE	E2	Spence Bay, Boothia Pen.
SVA	B2	Svalbard (Norway)
THU	D1	Thule, Greenland
UNG	D2	George River, Ungava Bay
WHB	A1	Western Hudson Bay (Churchill)

IDENTIFICATION OF BASELINE LEVELS AND SPATIAL TRENDS OF ORGANOCHLORINE, HEAVY METAL AND RADIONUCLIDE CONTAMINANTS IN CARIBOU (*Rangifer tarandus*)

ORGANOCHLORINE, HEAVY METAL AND RADIONUCLIDE CONTAMINANT TRANSFER THROUGH THE LICHEN-CARIBOU-WOLF FOOD CHAIN

PROGRAM LEADER: B. Elkin, Department of Renewable Resources, Government of Northwest Territories

PROJECT PARTNERS: J. Walker, Department of Health, GNWT
D. Haffner, Great Lakes Institute, Windsor

OBJECTIVES:

1. To assess the exposure of caribou and the lichen-caribou-wolf food chain to organochlorine, heavy metal and radionuclide contaminants.

2. To establish baseline levels of organochlorine, heavy metal and radionuclide contaminants in lichen, several caribou tissues and several wolf tissues.

3. To determine spatial trends of these contaminants in caribou across the NWT.

4. To provide baseline contaminant data that will serve as the basis for ongoing monitoring of temporal trends in caribou.

5. To model the transfer of these contaminants through the lichen-caribou-wolf food chain.

DESCRIPTION:

Very little information is available on the contaminant load in terrestrial wildlife in the Canadian Arctic. The limited amount of residue information does not allow for any speculation on the presence or trends of specific contaminants, and the scarcity of metal or organic residue data for terrestrial mammals has been identified as on of the major data gaps in arctic contaminant research. The limited analyses that have been conducted on terrestrial species have indicated that a variety of contaminants are present, and warrant more comprehensive studies to establish baseline levels.

The position of caribou in the arctic food chain makes it a useful species for monitoring changes in terrestrial contamination. Caribou are strict herbivores that have a winter diet made up primarily of lichen. Lichens have a long lived surface and accumulate atmospheric contaminants in a non-selective manner, resulting in a contaminant load similar to atmospheric input

through long range transport. The direct lichen-caribou-wolf food chain is ideally suited to monitor the deposition of contaminants in the terrestrial ecosystem and the subsequent transfer through several trophic levels. The defined ranges and distribution of caribou herds across the Northwest Territories also make it an ideal species for the examination of spatial trends of contaminants in the terrestrial ecosystem.

Caribou are a major component of the traditional diet of native people in inland and coastal communities across the Northwest Territories. Baseline data on contaminant levels is caribou tissues is needed to direct and support the evaluation of human exposure to contaminants through the consumption of caribou as a country food. The very limited data that currently exists for contaminants in terrestrial species is generally insufficient to provide dietary exposure data for native people.

This study will provide important baseline levels and spatial trends of organochlorine, heavy metal and radionuclide contaminants in caribou across the NWT. Baseline levels of contaminants will also be established for the three trophic levels of the lichen-caribou-wolf food chain, which will be used to model the transfer of these contaminants through this important arctic food chain. The baseline data established will serve as a basis for ongoing monitoring of temporal trends of contaminants in caribou.

ACTIVITIES:

This project was initiated in the fall of 1991, with AES Contaminants Program funding allocated in October 1991. The initial planning and consultation process began in 1991, and field collections were completed at two study locations. During 1992/93, the project will be in full operation with complete field and analytical components.

Sample collection

The geographical distribution of contaminants in the terrestrial ecosystem will be evaluated by examining caribou at eight sample locations across the Northwest Territories representing eight major caribou herds. Samples were collected from Coral Harbour and the Bathurst herd in 1991/92. Field collections will occur in Lake Harbour/Cape Dorset and Arviat in 1992/93, with additional collections over the next three years at Cambridge Bay, Pond Inlet, Inuvik and Spence Bay.

A sample size of 10 male and 10 female caribou are collected at each site, with equal representation from various age classes. Muscle, liver, kidney and fat samples as collected from each animal. Teeth are collected for aging, and rumen contents are collected for diet composition analysis. A variety of reproductive, biological and morphometric measurements are also recorded.

The lichen-caribou-wolf food chain will be examined at three sample locations across the NWT beginning in 1992/93. Samples will be collected from Fort Reliance in 1992/93, Inuvik in 1993/94 and Cambridge Bay in 1993/94. Wolves will be collected by local hunters, and submitted to the principal investigator. Muscle, liver, kidney and fat samples will then be forwarded for contaminant analyses.

Analysis

The study will initially involve broad-spectrum screening for organochlorine, heavy metal and radionuclide contaminants. In both caribou and wolves, organochlorine analysis will be conducted on muscle, liver and fat samples in order to evaluate tissue distribution resulting from considerable seasonal body fat fluctuations. Selected samples will be analyzed for co-planar PCB's. Heavy metal analysis will be run on liver and kidney. A full spectrum of analyses will also be conducted on a selected species of lichen. A QA/QC program will be conducted based on the recommendations of CWS-NWRC.

In 1991/92, tissue samples from 10 caribou were forwarded to the Great Lakes Institute for contaminant analyses. Thirty additional samples collected in 1991/92 were frozen and stored for analysis in 1992/93. Sample analysis is currently being completed, and final results are not yet available.

RESULTS AND FUTURE DIRECTIONS:

The 1991/92 field collections were completed on schedule, and contaminant analyses are currently underway on samples from 10 of the 40 caribou collected. Complete results are expected in early 1992/93.

1992/93 will be the second complete year of the study. Field collections of caribou will occur at Cape Dorset/Lake Harbour and Arviat, and wolves will be collected from Fort Reliance. Lichen samples will be collected from the two initial caribou collection sites. These samples and the 30 caribou samples stored in 1991/92 will be analyzed during the 1992/93 fiscal year.

Expected project completion date: This project is scheduled to occur over a six year period. Field collections will be completed in 1995/96, with final completion of the project at the end of 1996/97.

RESOURCES EXPENDED: ($K) (1991/92)

AES - Contaminants Program	
Contract Services	13.0
Supplies/Services	34.0
Travel/Transport	3.0
	50.0
GNWT-DRR A-Base	
PY's	0.3
Salary	15.0
O&M	10.0
	25.0

CONTAMINANTS IN WATERFOWL: NATIVE HARVEST IN NUNAVIK REGION, QUEBEC

PROJECT LEADER: B.M. Braune, National Wildlife Research Centre, Canadian Wildlife Service, Environment Canada

CONTRACTOR: Makivik Corporation, Kuujjuaq Research Centre, Kuujjuaq, Québec, organized and supervised all collections.

SUPPORTING AGENCIES: Indian and Northern Affairs Canada
Health and Welfare Canada

OBJECTIVES:

To address Inuit concerns in the Nunavik Region of northern Quebec with regard to contaminant levels in their food through collection and chemical analysis of the game birds and eggs hunted and eaten by those people. The chemical data for the collected birds and eggs will be submitted to Health and Welfare Canada so that the risk to human health of eating those birds may be assessed, and so that consumption advisories may be issued, if necessary.

PROJECT DESCRIPTION:

As part of the survey of contaminants in wild foods (waterfowl/game birds) currently being carried out by the Canadian Wildlife Service, 22 collections of waterfowl were made from 13 sites across the Northwest and Yukon Territories between 1988 and 1990. Those collections have been previously summarized in reports to Indian and Northern Affairs Canada. Those data are currently being evaluated by Health and Welfare Canada for risk to human health of eating those waterfowl.

In 1991-92, a total of 66 collections (both eggs and game birds) from six native communities in Nunavik, northern Québec, were proposed. To date, 33 collections have been received from northern Québec plus a collection each of Canada and Lesser Snow Geese from Arviat (Eskimo Point) (Table 1). The reason that only 50% of the collections requested from northern Québec have been made to date is that two of the six communities participating in the survey turned in no or only one collection. As well, due to the late transfer of funds to departments, spring collections could not be organized in time (only 5 of 20 proposed egg collections and 2 of 10 proposed spring bird collections were completed). Makivik Corporation has assured us, however, that compensatory spring collections will be made in 1992 as well as fall collections from the two communities where organizational difficulties were encountered last year.

All tissue preparation was carried out at the National Wildlife Research Centre, Hull, Québec. Samples of egg contents and breast muscle are being analyzed by pools for organochlorines under contract by the Great Lakes Institute, University of Windsor. Mercury, cadmium and lead are being analyzed by the National Wildlife Research Centre laboratories, and selenium and arsenic are being analyzed under contract by Fenwick Laboratories Limited, Halifax, N.S. All contract laboratories meet the quality assurance standards set by the Laboratory Services Section at the National Wildlife Research Centre. Where adequate tissue was available, samples of breast muscle were sent to the Bureau of Radiation and Medical Devices, Health and Welfare Canada, for radiocesium analyses. As well, the gastro-intestinal tracts were sent to the University of Québec at Rimouski as part of a waterfowl feeding study.

We do not yet have any results for the metal or radiocesium analyses. Of the organochlorine results received to date (Table 2), *trans*-chlordane and gamma-HCH were not detected (<0.001 mg/kg wet weight) in any of the muscle samples whereas only *trans*-chlordane was not detected in any of the egg samples. Among the egg samples, the highest levels of DDE, mirex, oxychlordane and PCBs (as Aroclor 1254:1260, 1:1) were found in Herring Gull eggs from Kangiqsualuujjuaq (1.52, 0.027, 0.058, 10.07 mg/kg, respectively) whereas the highest hexachlorobenzene level was found in Thick-billed Murre eggs from Digges Island (0.077 mg/kg). The values for Herring Gull eggs are similar to recent levels found in eggs from some of the colonies in the Great Lakes, and the levels found in the murre eggs are similar to levels found in Thick-billed Murre eggs collected from Prince Leopold Island in 1988. Among the samples of breast muscle, the highest levels of DDE and PCBs (as Aroclor 1254:1260) were found in Red-breasted Merganser from Kangiqsualuujjuaq (0.943 mg DDE/kg, 3.44 mg PCB/kg), Herring Gulls from Kuujjuaraapik (0.687 mg DDE/kg, 6.28 mg PCB/kg), Common Loons from Inukjuaq (0.453 mg DDE/kg, 3.25 mg PCB/kg), and Glaucous Gulls from Inukjuaq (0.345 mg DDE/kg, 17.29 mg PCB/kg). Levels in Common Loons and Red-breasted Mergansers are similar to levels found in breast muscle of those species collected from northern Ontario lakes during 1988-90. All chemical data from the birds collected from the Nunavik Region will be submitted to Health and Welfare Canada in fall 1992 for evaluation of risk to human health of eating those birds and eggs.

As part of the continuing survey of contaminants in waterfowl/game birds being conducted by the Canadian Wildlife Service, a survey of aquatic and game birds consumed by the native people of Labrador is currently being planned for 1992-93. Collections are being organized through the Labrador Inuit Association.

Expected project completion date: Tentatively 1994

RESOURCES:

	1989/90	1990/91	1991/92	1992/93
DIAND ($K)	20	11	60	32

The Canadian Wildlife Service has absorbed all other costs to date.

Table 1. Collections of birds received to date for the 1991-92 survey.

SPECIES	N	DATE	LOCATION
EGGS			
Canada Goose	1	07/91	Kangiqsualuujjuaq
Common Eider	4	07/91	"
Herring Gull	5	06/91	"
Black Guillemot	5	07/91	"
Thick-billed Murre	5	07/91	Ivujivik (Digges I)
BIRDS			
Common Eider	6	07/91	Kangiqsualuujjuaq
Red-throated Loon	2	07/91	"
Common Loon	3	07-8/91	"
Red-breasted Merganser	1	06/91	"
Black Guillemot	5	07/91	"
Oldsquaw	5	07/91	"
Canada Goose	5	07/91	"
Ptarmigan	5	01/92?	"
Common Loon	2	?	Salluit
Common Eider	3	?	"
King Eider	1	?	"
Thick-billed Murre	4	?	"
Snow Goose	4	06/91	"
Canada Goose	1	?	"
Herring Gull	3	08/91	Kuujjuaraapik
Thick-billed Murre	5	07/91	Ivujivik
Snow Goose	2	09/91	Inukjuaq
Canada Goose	4	09/91	"
Common Eider	3	09/91	"
King Eider	2	10/91	"
Common Loon	3	10/91	"
Black Scoter	5	09/91	"
Oldsquaw	5	10/91	"
Red-breasted Merganser	5	09/91	"
Herring Gull	2	09/91	"
Glaucous Gull	3	09/91	"
Black Guillemot	5	07-8/91	"
Canada Goose	2	05-6/91	Arviat (Eskimo Point)
Lesser Snow Goose	15	05-6/91	"

TABLE 2. ORGANOCHLORINES IN WATERFOWL COLLECTED FROM NORTHERN QUEBEC 1991

Wet Weight Basis (mg/kg or ppm)

I.D.	Tiss	Species	Age	Sex	N	Date mo	yr	Lat	Long	Prov/ Terr	Location	% Water	% Lipid
49246	BM	Canada Goose	1Ad,1Im	1F,1M	2	5/6	91	6107	09403	NWT	Arviat (Eskimo Point)	72.7	3.00
49331	BM	Lesser Snow Goose	1Im	1F	1	5/6	91	6107	09403	NWT	Arviat (Eskimo Point)	68.5	5.09
49333	BM	Lesser Snow Goose	7Ad	7F	7	5/6	91	6107	09403	NWT	Arviat (Eskimo Point)	68.8	5.25
49332	BM	Lesser Snow Goose	7Ad	7M	7	5/6	91	6107	09403	NWT	Arviat (Eskimo Point)	68.5	5.16
49490	EGG	Thick-billed Murre	---	---	1	7	91	6235	07750	NWT	Digges Island	74.1	11.94
49492	EGG	Thick-billed Murre	---	---	1	7	91	6235	07750	NWT	Digges Island	71.5	14.63
49491	EGG	Thick-billed Murre	---	---	1	7	91	6235	07750	NWT	Digges Island	71.9	16.54
49489	EGG	Thick-billed Murre	---	---	1	7	91	6235	07750	NWT	Digges Island	73.3	12.93
49493	EGG	Thick-billed Murre	---	---	1	7	91	6235	07750	NWT	Digges Island	73.0	13.00
50165	BM	Black Guillemot	5Ad	5M	5	7/8	91	5827	07805	Que	Inukjuaq	71.0	2.81
50179	BM	Black Guillemot	5Ad	4F,1M	5	7	91	5842	06557	Que	Kangiqsualuujjuaq (George River)	70.8	2.61
51769	BM	Black Scoter	5Ad	5F	5	9	91	5827	07805	Que	Inukjuaq	72.0	5.25
51979	BM	Canada Goose	2Ad	2F	2	9	91	5827	07805	Que	Inukjuaq	73.2	3.77
51978	BM	Canada Goose	2Im	2M	2	9	91	5827	07805	Que	Inukjuaq	74.0	2.99
50258	BM	Canada Goose	4Ad,1Im	4F,1M	5	7	91	5842	06557	Que	Kangiqsualuujjuaq (George River)	71.3	3.10
51805	BM	Canada Goose	1Im	1M	1	???	91	6214	07538	Que	Salluit	73.9	3.75
51783	BM	Common Eider	3Ad	3F	3	9/10	91	5827	07805	Que	Inukjuaq	77.2	2.04
50172	BM	Common Eider	6Ad	5F,1M	6	7	91	5842	06557	Que	Kangiqsualuujjuaq (George River)	72.0	2.62
51789	BM	Common Eider	3Ad	1F,2M	3	???	91	6214	07538	Que	Salluit	70.7	2.52
51845	BM	Common Loon	3Im	1F,2U	3	10	91	5827	07805	Que	Inukjuaq	69.9	6.07
50252	BM	Common Loon	1Ad	1M	1	8	91	5827	07805	Que	Inukjuaq	70.1	3.67
50192	BM	Common Loon	3Ad	2F,1M	3	7	91	5842	06557	Que	Kangiqsualuujjuaq (George River)	71.0	3.22
51848	BM	Common Loon	2Ad	1F,1M	2	???	91	6214	07538	Que	Salluit	66.4	5.87
51569	BM	Glaucous Gull	1Ad	1F	1	9	91	5827	07805	Que	Inukjuaq (garbage dump)	69.3	7.66
51570	BM	Glaucous Gull	1Im	1F	1	9	91	5827	07805	Que	Inukjuaq (garbage dump)	72.0	5.01
51568	BM	Glaucous Gull	1Im	1F	1	9	91	5827	07805	Que	Inukjuaq (garbage dump)	71.1	6.07
51573	BM	Herring Gull	1Ad	1F	1	9	91	5827	07805	Que	Inukjuaq (garbage dump)	70.4	6.11
51572	BM	Herring Gull	1Im	1F	1	9	91	5827	07805	Que	Inukjuaq (garbage dump)	72.0	4.70
50528	BM	Herring Gull	3Ad	2F,1M	3	8	91	5529	07731	Que	Kuujjuaraapik	74.0	2.88
51785	BM	King Eider	1Ad	1F	1	10	91	5827	07805	Que	Inukjuaq	74.0	3.41
51780	BM	King Eider	1Im	1M	1	9	91	5827	07805	Que	Inukjuaq	72.1	3.59
51784	BM	King Eider	1Ad	1M	1	???	91	6214	07538	Que	Salluit	72.4	1.85

Wet Weight Basis (mg/kg or ppm)

I.D.	Tiss	Species	Age	Sex	N	Date mo	Date yr	Lat	Long	Prov/ Terr	Location	% Water	% Lipid
51796	BM	Lesser Snow Goose	1Ad	1F	1	9	91	5827	07805	Que	Inukjuaq	73.1	4.17
51797	BM	Lesser Snow Goose	1Im	1M	1	9	91	5827	07805	Que	Inukjuaq	72.5	3.62
51795	BM	Lesser Snow Goose	4Ad	1F,3M	4	6	91	6214	07538	Que	Salluit	71.4	3.45
51980	BM	Oldsquaw	4Im	3F,1M	4	10	91	5827	07805	Que	Inukjuaq	73.4	2.79
51521	BM	Oldsquaw	1Ad	1F	1	10	91	5827	07805	Que	Inukjuaq	75.1	3.04
50357	BM	Oldsquaw	5Ad	3F,2M	5	7	91	5842	06557	Que	Kangiqsualuujjuaq (George River)	72.0	3.32
51981	BM	Red-breasted Merganser	4Ad	4F	4	9	91	5827	07805	Que	Inukjuaq	71.9	3.73
51803	BM	Red-breasted Merganser	1Im	1M	1	9	91	5827	07805	Que	Inukjuaq	72.1	3.91
50259	BM	Red-breasted Merganser	1Ad	1M	1	6	91	5842	06557	Que	Kangiqsualuujjuaq (George River)	71.0	3.52
50195	BM	Red-throated Loon	2Ad	2M	2	6/7	91	5842	06557	Que	Kangiqsualuujjuaq (George River)	69.3	6.34
49500	BM	Thick-billed Murre	5Ad	3F,2M	5	7	91	6224	07755	Que	Ivujivik	71.0	2.96
51778	BM	Thick-billed Murre	4Ad	1F,3M	4	???	91	6214	07538	Que	Salluit	69.7	3.29
50094	EGG	Black Guillemot	---	---	1	7	91	5842	06557	Que	George River (Kangiqsualuujjuaq)	73.3	11.82
50093	EGG	Black Guillemot	---	---	1	7	91	5842	06557	Que	George River (Kangiqsualuujjuaq)	74.7	9.61
50095	EGG	Black Guillemot	---	---	1	7	91	5842	06557	Que	George River (Kangiqsualuujjuaq)	73.7	11.44
50091	EGG	Black Guillemot	---	---	1	7	91	5842	06557	Que	George River (Kangiqsualuujjuaq)	72.3	11.69
50092	EGG	Black Guillemot	---	---	1	7	91	5842	06557	Que	George River (Kangiqsualuujjuaq)	74.2	10.75
50102	EGG	Canada Goose	---	---	1	7	91	5842	06557	Que	Kangiqsualuujjuaq (George River)	65.1	19.81
50107	EGG	Common Eider	---	---	4	7	91	5842	06557	Que	Kangiqsualuujjuaq (George River)	67.0	18.50
50111	EGG	Herring Gull	---	---	1	6	91	5842	06557	Que	George River	75.8	9.39
50112	EGG	Herring Gull	---	---	1	6	91	5842	06557	Que	George River	76.4	10.27
50110	EGG	Herring Gull	---	---	1	6	91	5842	06557	Que	George River	76.7	9.63
50108	EGG	Herring Gull	---	---	1	6	91	5842	06557	Que	George River	75.8	11.56
50109	EGG	Herring Gull	---	---	1	6	91	5842	06557	Que	George River	76.0	9.70

ND < 0.001 mg/kg

BM - Breast Muscle, Ad - Adult, Im - Immature, F - Female, M - Male, U - Unknown

Wet Weight Basis (mg/kg or ppm)

I.D.	Tiss	Species	1,2,4,5 -T4CB	1,2,3,4 -T4CB	QCB	HCB	OCS	photo-Mirex	Mirex	a-HCH	b-HCH	g-HCH
49246	BM	Canada Goose	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
49331	BM	Lesser Snow Goose	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
49333	BM	Lesser Snow Goose	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
49332	BM	Lesser Snow Goose	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
49490	EGG	Thick-billed Murre	0.002	0.001	0.002	0.077	0.009	0.002	0.003	0.006	0.007	0.001
49492	EGG	Thick-billed Murre	0.001	ND	0.003	0.060	0.004	ND	0.001	0.001	0.005	ND
49491	EGG	Thick-billed Murre	0.002	0.002	0.003	0.059	0.007	ND	0.002	0.010	0.005	0.001
49489	EGG	Thick-billed Murre	0.002	0.003	0.004	0.058	0.007	ND	0.002	0.007	0.006	0.001
49493	EGG	Thick-billed Murre	0.002	0.001	0.003	0.060	0.007	ND	0.002	0.003	0.006	0.001
50165	BM	Black Guillemot	ND	ND	ND	0.016	0.003	ND	0.001	0.001	ND	ND
50179	BM	Black Guillemot	ND	ND	ND	0.019	0.003	ND	ND	0.001	0.001	ND
51769	BM	Black Scoter	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
51979	BM	Canada Goose	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
51978	BM	Canada Goose	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
50258	BM	Canada Goose	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
51805	BM	Canada Goose	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
51783	BM	Common Eider	ND	ND	ND	0.001	ND	ND	ND	ND	ND	ND
50172	BM	Common Eider	ND	ND	ND	0.003	ND	ND	ND	ND	ND	ND
51789	BM	Common Eider	ND	ND	ND	0.005	ND	ND	ND	0.001	ND	ND
51845	BM	Common Loon	ND	ND	ND	0.018	ND	ND	ND	ND	ND	ND
50252	BM	Common Loon	ND	ND	0.001	0.016	0.003	0.032	0.004	ND	ND	ND
50192	BM	Common Loon	ND	ND	ND	0.008	0.002	0.018	0.029	ND	ND	ND
51848	BM	Common Loon	ND	ND	ND	0.119	0.002	ND	0.001	ND	0.001	ND
51569	BM	Glaucous Gull	ND	ND	ND	0.013	0.003	ND	0.011	ND	0.001	ND
51570	BM	Glaucous Gull	0.002	ND	0.001	0.014	0.003	ND	0.008	0.002	0.003	ND
51568	BM	Glaucous Gull	ND	0.003	0.002	0.042	0.006	ND	0.010	ND	0.003	ND
51573	BM	Herring Gull	ND	ND	ND	0.010	0.002	ND	0.018	ND	0.002	ND
51572	BM	Herring Gull	ND	ND	ND	0.021	0.021	ND	0.004	ND	ND	ND
50528	BM	Herring Gull	ND	ND	0.001	0.026	0.002	0.061	0.023	ND	0.002	ND
51785	BM	King Eider	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
51780	BM	King Eider	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
51784	BM	King Eider	ND	ND	0.001	0.014	ND	0.001	ND	ND	0.003	ND

Wet Weight Basis (mg/kg or ppm)

I.D.	Tiss	Species	1,2,4,5 -T4CB	1,2,3,4 -T4CB	QCB	HCB	OCS	photo-Mirex	Mirex	a-HCH	b-HCH	g-HCH
51796	BM	Lesser Snow Goose	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
51797	BM	Lesser Snow Goose	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
51795	BM	Lesser Snow Goose	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
51980	BM	Oldsquaw	ND	ND	ND	ND	ND	ND	ND	0.002	ND	ND
51521	BM	Oldsquaw	ND	ND	ND	0.003	ND	ND	ND	0.002	0.001	ND
50357	BM	Oldsquaw	ND	ND	ND	0.006	ND	0.004	0.001	0.006	ND	ND
51981	BM	Red-breasted Merganser	ND	ND	ND	0.001	ND	ND	ND	ND	ND	ND
51803	BM	Red-breasted Merganser	ND	ND	ND	0.002	ND	ND	ND	ND	ND	ND
50259	BM	Red-breasted Merganser	ND	ND	ND	0.011	0.003	0.083	0.185	ND	ND	ND
50195	BM	Red-throated Loon	ND	ND	0.001	0.014	0.003	0.022	0.003	ND	ND	ND
49500	BM	Thick-billed Murre	ND	ND	0.001	0.023	0.002	ND	ND	ND	0.001	ND
51778	BM	Thick-billed Murre	ND	ND	ND	0.016	0.002	ND	ND	0.001	0.001	ND
50094	EGG	Black Guillemot	ND	0.001	0.002	0.032	0.005	ND	0.002	0.002	0.006	0.001
50093	EGG	Black Guillemot	ND	ND	0.001	0.020	0.003	0.001	0.002	0.002	0.004	ND
50095	EGG	Black Guillemot	ND	0.002	0.002	0.047	0.006	ND	0.003	0.005	0.003	ND
50091	EGG	Black Guillemot	ND	ND	ND	0.017	0.003	0.001	0.002	0.002	0.004	ND
50092	EGG	Black Guillemot	ND	ND	ND	0.016	0.003	0.001	0.002	0.003	0.004	ND
50102	EGG	Canada Goose	ND	ND	0.001	0.007	ND	ND	ND	ND	0.002	ND
50107	EGG	Common Eider	ND	ND	0.001	0.007	ND	ND	ND	ND	0.001	ND
50111	EGG	Herring Gull	0.002	0.001	0.002	0.020	0.003	ND	0.006	ND	0.002	ND
50112	EGG	Herring Gull	ND	ND	0.001	0.028	0.004	ND	0.027	ND	0.003	ND
50110	EGG	Herring Gull	ND	0.001	0.001	0.025	0.005	ND	0.027	ND	0.002	ND
50108	EGG	Herring Gull	ND	ND	0.002	0.051	0.005	ND	0.008	ND	0.003	ND
50109	EGG	Herring Gull	ND	0.001	0.001	0.021	0.005	ND	0.003	ND	0.001	ND

Wet Weight Basis (mg/kg or ppm)

I.D.	Tiss	Species	oxy-Chlordane	cis-Chlordane	trans-Chlordane	cis-Nonachlor	trans-Nonachlor	pp'-DDD	pp'-DDT	pp'-DDE	HE	Dieldrin	Aroclor 1254:1260	SUM PCB Congeners
49246	BM	Canada Goose	0.001	ND	ND	ND	ND	ND	ND	0.001	0.001	ND	0.004	0.004
49331	BM	Lesser Snow Goose	ND	ND	ND	ND	ND	ND	ND	0.002	ND	ND	0.002	ND
49333	BM	Lesser Snow Goose	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.001	0.002	ND
49332	BM	Lesser Snow Goose	ND	ND	ND	ND	ND	ND	ND	0.001	ND	0.001	0.002	ND
49490	EGG	Thick-billed Murre	0.034	0.002	ND	0.010	0.005	0.002	0.015	0.249	0.010	0.020	0.269	0.168
49492	EGG	Thick-billed Murre	0.026	ND	ND	0.003	0.001	0.001	0.003	0.152	0.006	0.012	0.278	0.137
49491	EGG	Thick-billed Murre	0.028	0.002	ND	0.007	0.004	0.002	0.011	0.145	0.011	0.024	0.372	0.172
49489	EGG	Thick-billed Murre	0.031	0.002	ND	0.007	0.004	0.001	0.011	0.165	0.012	0.030	0.394	0.179
49493	EGG	Thick-billed Murre	0.035	0.002	ND	0.008	0.005	0.002	0.011	0.232	0.010	0.023	0.483	0.226
50165	BM	Black Guillemot	0.006	ND	ND	0.006	0.004	ND	0.006	0.029	0.004	0.003	0.112	0.060
50179	BM	Black Guillemot	0.008	ND	ND	0.005	0.005	ND	0.007	0.022	0.005	0.005	0.095	0.050
51769	BM	Black Scoter	ND	ND	ND	ND	ND	ND	ND	0.001	ND	ND	0.003	0.001
51979	BM	Canada Goose	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
51978	BM	Canada Goose	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
50258	BM	Canada Goose	ND	ND	ND	ND	ND	ND	ND	0.004	ND	ND	0.004	0.003
51805	BM	Canada Goose	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
51783	BM	Common Eider	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.003	0.001
50172	BM	Common Eider	0.002	ND	ND	ND	ND	ND	0.003	0.006	ND	ND	0.030	0.014
51789	BM	Common Eider	0.003	ND	ND	ND	ND	ND	0.001	0.005	0.001	ND	0.019	0.009
51845	BM	Common Loon	ND	ND	ND	ND	0.001	ND	ND	0.002	ND	0.002	0.020	0.010
50252	BM	Common Loon	0.019	0.002	ND	0.019	0.057	0.006	0.005	0.453	0.007	0.033	3.254	1.361
50192	BM	Common Loon	0.006	ND	ND	0.005	0.019	0.005	0.003	0.241	0.003	0.020	1.144	0.582
51848	BM	Common Loon	0.008	0.002	ND	0.003	0.009	0.002	0.002	0.069	0.007	0.055	0.810	0.340
51569	BM	Glaucous Gull	0.055	ND	ND	ND	0.004	ND	0.003	0.605	0.008	0.005	1.865	0.896
51570	BM	Glaucous Gull	0.163	ND	ND	0.004	0.028	0.006	0.014	0.497	0.027	0.017	1.511	0.972
51568	BM	Glaucous Gull	0.159	0.001	ND	0.012	0.054	ND	0.038	0.345	0.045	0.158	17.289	0.989
51573	BM	Herring Gull	0.105	ND	ND	ND	0.006	ND	0.002	0.608	0.020	0.006	2.848	1.641
51572	BM	Herring Gull	0.042	ND	ND	0.003	0.015	0.002	0.010	0.366	0.010	0.008	1.367	0.671
50528	BM	Herring Gull	0.083	ND	ND	0.003	0.011	0.002	0.009	0.687	0.015	0.011	6.281	2.419
51785	BM	King Eider	ND	ND	ND	ND	ND	ND	ND	ND	0.001	ND	0.002	0.003
51780	BM	King Eider	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.003	0.004
51784	BM	King Eider	0.007	ND	ND	ND	0.002	ND	0.003	0.014	0.002	ND	0.053	0.030

Wet Weight Basis (mg/kg or ppm)

I.D.	Tiss	Species	oxy-Chlordane	cis-Chlordane	trans-Chlordane	cis-Nonachlor	trans-Nonachlor	pp'-DDD	pp'-DDT	pp'-DDE	HE	Dieldrin	Aroclor 1254:1260	SUM PCB Congeners
51796	BM	Lesser Snow Goose	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
51797	BM	Lesser Snow Goose	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
51795	BM	Lesser Snow Goose	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
51980	BM	Oldsquaw	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
51521	BM	Oldsquaw	0.003	ND	ND	ND	0.001	ND	0.001	0.018	0.004	0.003	0.105	0.055
50357	BM	Oldsquaw	0.009	ND	ND	ND	0.003	ND	ND	0.048	ND	0.006	0.225	0.124
51981	BM	Red-breasted Merganser	0.001	ND	ND	ND	ND	ND	0.001	0.006	0.002	0.002	0.028	0.015
51803	BM	Red-breasted Merganser	0.001	ND	ND	ND	ND	ND	ND	0.004	ND	ND	0.021	0.010
50259	BM	Red-breasted Merganser	0.025	ND	ND	ND	ND	0.002	0.005	0.943	0.003	0.003	3.439	1.738
50195	BM	Red-throated Loon	0.012	0.001	ND	0.008	0.050	0.005	0.006	0.287	0.007	0.031	1.875	0.839
49500	BM	Thick-billed Murre	0.007	ND	ND	ND	ND	ND	ND	0.080	ND	0.002	0.138	0.073
51778	BM	Thick-billed Murre	0.007	ND	ND	ND	ND	ND	ND	0.040	0.001	0.003	0.070	0.037
50094	EGG	Black Guillemot	0.025	0.001	ND	0.022	0.010	0.002	0.023	0.057	0.018	0.018	0.260	0.148
50093	EGG	Black Guillemot	0.023	ND	ND	0.013	0.006	ND	0.014	0.035	0.017	0.013	0.201	0.107
50095	EGG	Black Guillemot	0.022	0.004	ND	0.018	0.038	0.002	0.024	0.076	0.027	0.022	0.340	0.186
50091	EGG	Black Guillemot	0.018	ND	ND	0.011	0.005	ND	0.012	0.041	0.013	0.009	0.220	0.111
50092	EGG	Black Guillemot	0.017	ND	ND	0.010	0.005	ND	0.013	0.039	0.012	0.009	0.214	0.099
50102	EGG	Canada Goose	0.010	ND	ND	ND	0.007	ND	ND	0.017	0.005	0.014	0.085	0.046
50107	EGG	Common Eider	0.005	ND	ND	ND	0.003	ND	ND	0.011	0.005	0.009	0.059	0.028
50111	EGG	Herring Gull	0.040	0.003	ND	0.009	0.040	ND	0.009	0.529	0.018	0.022	3.745	1.639
50112	EGG	Herring Gull	0.058	0.002	ND	0.005	0.057	ND	0.005	1.360	0.029	0.013	10.067	4.232
50110	EGG	Herring Gull	0.045	0.003	ND	0.012	0.039	0.003	0.023	1.522	0.023	0.019	8.616	4.071
50108	EGG	Herring Gull	0.040	0.002	ND	0.012	0.078	ND	0.010	0.689	0.028	0.020	6.137	2.569
50109	EGG	Herring Gull	0.043	0.006	ND	0.011	0.045	0.002	0.019	0.402	0.018	0.047	3.279	1.461

POTENTIAL FOR EFFECTS ON REPRODUCTION, CARCINOGENESIS, MUTAGENESIS AND TERATOGENESIS IN ARCTIC MAMMALS: STATUS OF BIOMARKERS IN ARCTIC SEALS AND WHALES

PROGRAM LEADER: J. Payne, Fisheries and Oceans Canada

PROJECT TEAM: (in alphabetical order) L. Fancey, J. Hellou, J. Kiceniuk, S. Ray (contractor MUN)

OBJECTIVES:

To determine if the levels of contaminants in the Arctic are sufficiently high to engender concerns about reproductive failure and carcinogenesis, mutagenesis, and teratogenesis in marine mammals - the species at highest risk. To assess the present situation and provide a baseline on the critical biological indices that will be of paramount importance for a monitoring/assessment strategy for the Arctic.

DESCRIPTION:

Sublethal stressors can elicit physiological, immunological and pathological changes in vertebrates - changes which can lead to impairment of growth, cancer and reproductive functions. Responses to stressors are preceded by changes at the biochemical/molecular level and such changes can be used as either biomarkers or early warning indicators of impending problems.

Is there a cause for concern for contaminant mediated diseases in arctic animals, such as marine mammals which bioaccumulate inordinate amounts of persistent organochlorines? Investigations have revealed a dramatic decrease in reproductive capacity in ring, grey and harbour seals in the Baltic. Also, recent studies have demonstrated a high frequency of cancer and other pathological changes in beluga whales from the Gulf of St. Lawrence.

It is proposed to investigate the status of three important markers of biological damage in beluga whales, seals and walrus from arctic and Labrador waters. Where possible, such as for belugas, harbour seals and ringed seals, comparisons will be made in reference to animals from more heavily contaminated areas, namely the Gulf of St. Lawrence and the Baltic and Wadden Seas.

Given the known effect of contaminants on marine mammals from the North and Baltic Seas and the Gulf of St. Lawrence, the biomarkers identified as being important are biomarkers for reproduction (hormone receptor numbers) and cancer mutagenesis/effects (DNA-adducts, DNA oxidation and ras-oncoproteins).

A. Reproductive Effect Biomarkers

i. Steroid Receptors

The reproductive effects seen in seals from the North Sea are believed to be caused by the high level of organochlorines in their diet. Basic studies indicate that the molecular basis for reproductive effects may be at the hormone receptor level, which is decreased in animals exposed to organochlorines such as polychlorinated biphenyls.

ii. Vitamin A

Vitamin A is a critical vitamin for the maintenance of epithelial cells and as such is directly involved in modulating viral and bacterial infections, reproductive disorders, and other pathologies. Exposure of animals to elevated concentrations of chlorinated organics such as PCBs can result in depression of Vitamin A levels. Studies carried out by Dutch scientists suggest that the lethal viral infections and reproductive disorders in seals and other marine mammal populations in the Baltic, North and Wadden Seas are linked to Vitamin A and thyroid hormone imbalances. It is postulated that such imbalances can be effected through consumption of fish having elevated concentrations of chlorinated hydrocarbons.

B. Cancer/Mutagenesis Biomarkers

Sophisticated techniques are presently available for measuring pollutant mediated DNA damage. DNA damage can occur directly through covalent bonding of contaminants (or contaminant by-products) to selective nucleotides forming so-called DNA adducts. Alternatively, damage can occur indirectly through the formation of powerful oxidizing radicals which degrade nucleotide bases in DNA in a more or less characteristic manner. Organic compounds are primarily involved in DNA adduct formation while both heavy metals and organic compounds can be involved in radical formation.

Both chemical mediated DNA adduction and DNA oxidation are linked with organism carcinogenesis, mutagenesis and teratogenesis. (In this regard it is worth noting that DNA damage is most often emphasized but a theoretical basis exists for damage to other cellular macromolecules.) Techniques for measuring both DNA adduction and radical produced DNA damage have been established in St. John's in the past 3 years.

Ras-oncoprotein:

Many reports have shown that interaction of a variety of chemical carcinogens with DNA can lead to specific mutations resulting in oncogene activation. Results obtained with carcinogen-induced tumors and transgenic mice have indicated that ras-oncogene can participate in the initiation of carcinogenesis. The overexpression of total proto-oncoproteins such as ras and myc have been implicated in the pathogenesis of a number of neoplastic conditions.

ACTIVITIES IN 1989-92:

Vitamin A:

Vitamin A levels were determined in liver tissue of beluga whales from the MacKenzie and St. Lawrence Rivers. Three whales from the St. Lawrence were "depleted" in Vitamin A while one from the MacKenzie also contained very low levels (Figure 1).

Overall, there is indication that whales from the St. Lawrence may have lower vitamin levels but more information on Vitamin A stability in relation to time of animal death is required.

DNA adducts:

DNA was isolated from the liver of beluga using phenol based procedures and DNA adducts were determined using the nuclease P1 variant of the P-32 postlabelling assay. Briefly, DNA was digested to normal and adducted nucleotides with enrichment being carried out by selective destruction of normal nucleotides by nuclease P1. The remaining nucleotides were labelled with P-32 and separation was carried out by two dimensional then larger chromatography. Adduct spots were detected by autoradiography and adduct quantification was carried out with a gamma scintillation counter.

Levels of DNA adducts were determined in liver tissue of belugas from the Gulf of St. Lawrence, the St. Lawrence and Hudson Bay. Varying levels of adducts were detected in animals from all the sites. The pattern found in animals from East Hudson Bay, which ranged from a low of 10 units to a high of approximately 120 units, is noted in Figure 1. Adducts have also been observed in harp seals from waters around Newfoundland and Labrador. Of special note was the higher concentrations found in muscle and brain in comparison with liver tissues.

DNA Oxidation Damage:

DNA was isolated from the liver of beluga, acid hydrolyzed, and nucleotides were trimethylsilylated under an atmosphere of pure nitrogen. The TMS derivatives were subjected to gas chromatography - mass spectrometry with single-ion monitoring (GC-MS/SIM). Two indicators of oxidative damage, 8-hydroxy adenine and 4,6-diamino-5-formamidopyrimidine, were detected in beluga from the MacKenzie as well as the St. Lawrence.

CONCLUSIONS AND FUTURE DIRECTIONS:

Preliminary information has been obtained on the status of (a) Vitamin A in belugas from the MacKenzie and St. Lawrence Rivers, (b) DNA adducts in belugas from the MacKenzie and St. Lawrence Rivers and Hudson Bay, (c) DNA adducts in harp seals from waters around Newfoundland and Labrador, and (d) DNA oxidative damage in belugas from the MacKenzie and St. Lawrence Rivers. Additional studies are

required on a variety of tissues in different marine mammal species to determine if the biomarker differences being observed could have a chemical aetiology. The focus of attention in 1992/93 will be on obtaining more information on DNA oxidative damage.

RESOURCES: (received in 1991/92, 1992/93 and planned under Green Plan AES)

	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
$K	65	130	130	130	130	80

Spent 40 Allotted 80

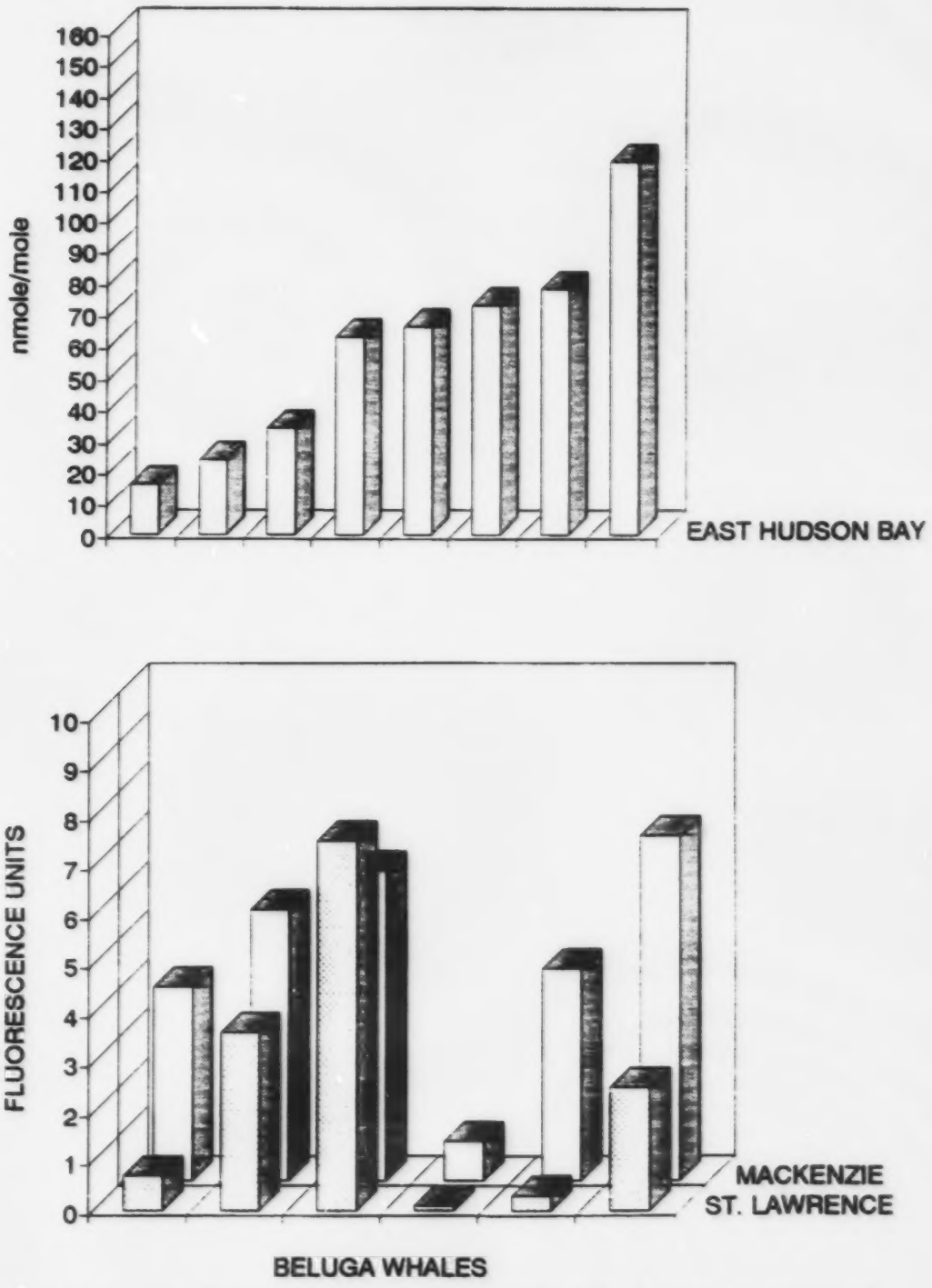

Figure 1. Top legend. Levels of aromatic DNA adducts in liver of beluga whales from Hudson Bay.

Bottom legend. Levels of Vitamin A in liver of beluga whales from MacKenzie and St. Lawrence Rivers.

MODELLING AND EVALUATION OF CONTAMINANT ACCUMULATION AND EFFECTS IN MARINE MAMMALS

PROGRAM LEADERS: P. Hodson and M. Kingsley, Fisheries and Oceans Canada, Quebec Region;
B. Hickie, Dept. of Biology, Trent University

PROJECT TEAM: P. Hodson, M. Kingsley, B. Hickie, D. Muir, D. Mackay

OBJECTIVES:

1. To develop a general contaminant accumulation model for arctic marine mammals.

2. To understand contaminant dynamics, direct contaminant monitoring programs, and to assist the assessment of the significance of marine mammals as a dietary source of contaminants to native peoples.

3. To provide a framework for assessing spatial and temporal trends in contaminant levels in arctic marine mammals.

4. To identify factors controlling contaminant accumulation from arctic food chains and identify further research needs.

DESCRIPTION:

Marine mammals are top level predators and accumulate high levels of persistent contaminants (including PCBs, DDT, toxaphene, Hg, Cd) from long-range transboundary air pollution (LRTAP), and local development in James Bay, Hudson Bay and remote settlements. The potential consequences of this may include toxicity to consumers of marine mammals.

A general energetics-based marine mammal model of contaminant accumulation would be highly useful in identifying present data gaps, directing contaminant sampling programs, and understanding processes of accumulation and differences in contaminant loading between species, locations and through time. This project will develop the model, identify critical factors unique to each species that affect contaminant accumulation, and collect data to refine the model. The initial work will provide a focus for related activities on marine mammals throughout the Department of Fisheries and Oceans (DFO), by drawing on existing data and by capitalizing on current research programs. It will consolidate and review present knowledge while identifying future needs in a rational framework.

ACTIVITIES IN 1991/92:

The initial stage of this work was done in association with Dr. Donald Mackay, from the University Toronto, under the St. Lawrence Action Plan. It adapted a standard mammalian multi-compartment pharmacokinetics model to suit the attributes of a beluga whale. The model identified the pathways of exposure (gut, lung), the efficiency of contaminant transfer, the distribution of contaminant within the body, and the routes of excretion from the whale (gut, metabolism in the liver, lung). The model effectively dealt with a wide variety of organic contaminants if their chemical characteristics (hydrophobicity, solubility, vapour pressure) were known. The utility of this model was limited by its narrow time frame (days to weeks) and the lack of data characterizing body compartments.

In 1991/92, the second stage of model development incorporated aspects of the life-history of the beluga (sex, energetics, diet, growth, reproduction). Consideration of the energy requirements and diet of beluga were critical aspects of the model since exposure to the contaminants of greatest concern (PCBs) are almost exclusively via the diet. Information necessary for modelling dietary accumulation of contaminants included: the feeding rate, efficiency of dietary energy assimilation, and the contaminant and energy content of prey items. For the most part, the data were estimated from scanty data and data from other species.

ACTIVITIES IN 1992/93:

The next stage of the project will adapt the energetics-pharmacokinetics model for the St. Lawrence beluga population to arctic populations/species (beluga, narwhal, ringed seal, walrus, bearded seal). Modelling will incorporate specific life-history, energetics, dietary, physiology, and reproductive biology information for each species, and will be calibrated to the present level of knowledge on contamination in these species and their prey. The model will identify the need for data on critical life-history aspects affecting contaminant accumulation (eg. age, sex, reproductive effort) and specific contaminant measurements in marine mammals and prey species. In subsequent years of the project, this information will be used to direct a sampling/analysis program to improve the model and our understanding of contaminant dynamics in arctic marine mammals. By concentrating on the similarities between species, the model will allow extension of results from easily-studied species to the less accessible species.

For beluga, contaminant transfer from mother to offspring is an important pathway of contaminant clearance which can explain observed differences in contaminant burdens between males and females. Preliminary modelling suggests that the calf at birth will have tissue contaminant concentrations similar to its mother, and can represent a loss of about 10% of the total contaminant burden of the female. Contaminant loss by lactation is likely much

greater than this, although precise estimation is difficult since the duration of lactation has been reported to range from 8 to 22 months. Using a lactation period of 18 months, maternal contaminant loss could be as high as 40% of the total body burden. Since contaminant levels increase with the age of the whale, calves of older females should be more contaminated. Thus the likelihood of contaminants affecting reproduction and calf survival should increase with the age of the female. To incorporate these factors in the model, published data on the milk of marine mammals will be sought and the model increased in its complexity.

RESULTS:

The output of the model developed for the St. Lawrence beluga was compared with measurements of chemical levels in beluga found dead along the shore, as reported in the literature. The model successfully tracked the changes in average levels of chemical contaminants with age in both male and female whales. As well, the model was easily manipulated to test the relative importance of different factors such as age, sex, numbers of births, contamination at birth, and different contamination levels in prey.

CONCLUSION AND UTILIZATION OF RESULTS:

The early results have shown that this model is a very useful tool for understanding and investigating the process and extent of chemical contamination of marine mammals. It will also be useful in driving sampling programs to fill critical data gaps and in identifying the highest priority research needs.

PUBLICATIONS/REPORTS:

Hickie, B.E. 1992. Modelling and evaluation of contaminant accumulation in the St. Lawrence Estuary beluga whale (*Delphinapterus leucas*). Contract Final Report to the Department of Fisheries and Oceans, Maurice Lamontagne Institute, Mont-Joli, Quebec. Contract #FP707-1-6530 (To be published as a DFO technical report).

Hickie, B.E., D. Mackay, P. Béland and P.V. Hodson. 1991. Modelling contaminant accumulation in the St. Lawrence Beluga. 12th Annual Meeting of the Society for Environmental Toxicology and Chemistry, Seattle, November, 1991.

Expected project completion date: March 31, 1997

RESOURCES: (received in 1991/92, 1992/93 and planned under Green Plan AES)

	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
$K	12	20	40	40	40	25

BIOCHEMICAL STRESS INDICATORS IN MARINE MAMMALS

PROGRAM LEADERS: W.L. Lockhart and R.E.A. Stewart, Fisheries and Oceans Canada

PROJECT TEAM: R. Wagemann, D.A. Metner, R.W. Danell, D. Kenny (contractor), C. Ford (contractor)

OBJECTIVES:

Short term: To define levels of biochemical stress responses in marine mammals as functions of contaminant concentrations measured in the same animals, and to define the influences of normal biological and habitat variables (eg. sex, age, size, etc.) on the ranges of biochemical values.

Long term: To understand the implications of contaminants (PCBs, chlorinated dioxins and furans, polycyclic aromatic hydrocarbons, heavy metals) for the health of individual arctic marine mammals, using biochemical stress markers (mixed-function oxidases for the organic contaminants and metallothioneins for the metals).

DESCRIPTION:

This project was established to examine a sensitive mammalian response to PCBs and other compounds structurally related to them in arctic marine mammals. It has been established that marine mammals have an active cytochrome P-450 system (Addison and Brodie, 1984; Addison *et al.*, 1986; Goksoyr *et al.*, 1986; Watanabe *et al.*, 1989;). There is limited experimental evidence to suggest that the system is inducible by petroleum in seals (Engelhardt, 1982), and there are correlations between enzymatic activity and residues of organochlorine compounds in Pacific Ocean dall's porpoises (Subramanian *et al.*, 1987).

The project is a continuation of previous ad-hoc efforts to the same end, beginning with a project funded by the Panel on Energy Research and Development in 1984 and 1985. The project is intended to include both field collections and laboratory analyses of tissues for cytochrome P-450-related catalytic activities. It is linked with other Arctic Environmental Strategy projects to which it supplies tissues. It relies on chemical residue measures of PCB congeners and other contaminants in the same individuals to test whether these exposures have been sufficient to produce statistical relationships between residues and enzyme activities. It also relies on biological descriptions of the marine mammals, taken at the time of collection.

No field work was undertaken in 1991/92. Funding came very late in the fiscal year and was used to support the analyses of samples

already on hand from opportunistic collections. The first of these was from a group of beluga whales which became trapped in a freshwater lake in the fall of 1989, and were killed by hunters rather than allowed to die as ice formed. A second set of samples was obtained by Dr. H. Welch (DFO, Winnipeg) in Creswell Bay in the summer of 1991 and consisted of several narwhal and three beluga. A third set of 43 fur seals from the Pribilof Islands was supplied by Dr. D. Kurtz from the University of Pennsylvania.

In the laboratory the fast-frozen liver samples were sub-samples for small quantities from which microsomes were prepared. Microsomal suspensions were then analyzed for two cytochrome P-450-related catalytic activities, namely ethoxyresorufin-O-deethylase (EROD) and aryl hydrocarbon hydroxylase (AHH), and for cytochrome P-450 content. A cytochrome P-450 difference spectrum was recorded for each specimen and is retained electronically. The laboratory work, like that with the fish, was hampered by excess down time with an old spectrofluorometer used for the EROD assay. A new instrument was leased late in the year, and should be operational within the first month of the new fiscal year.

RESULTS:

Microsomal enzymatic activities for the samples reported this year are tabulated below, along with other samples we have accumulated in other earlier programs. One of the objectives of the current program is to examine these enzymes systematically to see whether they vary significantly throughout the year, particularly with respect to reproductive status. We have two sets of results which suggest that at least there are differences between adult seals and young pups still nursing (Table 1).

Since these enzyme activities are proposed as sensitive early warnings of exposure to contaminants with structures required for enzyme induction, it was required to show that these enzymes do

Table 1. Microsomal enzyme activities (nmol/mg prot./min) in adults and pups taken during the nursing period in the Gulf of St. Lawrence (Harp seals, 1984) and at Sable Island (Grey seals, 1985).

	EROD	AHH	ODM
Harp seal adult females	0.207	0.056	0.436
Harp seal adult males	0.630	0.199	0.473
Harp seal nursing female pups	0.058	0.022	0.195
Harp seal nursing male pups	0.077	0.032	0.153
Grey seal adult females	0.070	0.041	---
Grey seal adult males	0.144	0.070	---
Grey seal nursing female pups	0.037	0.029	---
Grey seal nursing male pups	0.039	0.031	---

in fact respond as expected in a marine mammal. To this end, an experiment was conducted by injecting harp seal pups with crude oil and then sacrificing the pups and their mothers over a period of about three weeks after the initial injection. The injected pups had clearly elevated enzymatic activities when compared with untreated pups sampled at the same time (Table 2).

Table 2. Mean liver microsomal MFO activities (nmol/mg prot./min) of harp seal pups injected with Norman Wells crude oil, as compared with untreated controls.

		EROD	AHH	ODM
Female pups	Control	0.058	0.022	0.195
Male pups	Control	0.077	0.032	0.153
Female pups	Oil	2.81	0.225	0.764
Male pups	Oil	2.87	0.277	0.838

Enzymatic activities obtained for the remaining marine mammal samples are listed in Table 3. When the combined results from these analyses are presented on a map (Figure 1), two groups have high values, namely the two beluga collections, especially that from the Mackenzie Delta. The beluga in the Mackenzie Delta lake (Husky Lake) became trapped in freshwater and were taken by hunters; the alternative was to let them suffocate as ice formed. When taken, these beluga were noted to be in an emaciated condition. On average they were about 200 kg lighter in weight than other collections of beluga of comparable length. This raises the obvious question of whether mobilization of blubber to meet metabolic needs might release some of the contaminants normally stored in blubber.

Table 3. Mean liver microsomal MFO activities for several marine mammal collections.

Species	Sex	N	Location	EROD	AHH
Narwhal	males	8	Creswell Bay	0.188	0.061
Beluga	male	1	Creswell Bay	0.427	0.163
Beluga	female	2	Creswell Bay	0.910	0.230
Beluga	male	5	Husky Lake	1.087	0.224
Beluga	female	4	Husky Lake	0.345	0.084
Fur seals	??	42	Pribilof Islands	0.222	0.093

Very recently we obtained data on the most active PCB congeners in blubber from the beluga collected in the Mackenzie Delta (Table 4) along with the MFO enzyme activities for the same individuals. Statistically there were highly significant relationships between the PCB congeners and the enzymatic activities. A simple model relating the EROD activity to the sum of the non-ortho and mono-ortho congeners, with no weighting of congeners for toxic potency in mammalian systems, gave an R-square value of 0.793. A sample plot of EROD activity against the sum of these congeners is given in Figure 2. In a correlation analysis, both EROD ($r=0.89$, $p<0.0001$) and AHH ($r=0.87$, $p<0.0001$) correlated strongly with the total of these PCB congeners. Even cytochrome P-450 levels were related to the congeners ($r=0.81$, $p=0.0008$). Such strong associations do not prove that a causal relationship existed between the PCBs and the enzymatic activities, however, such a relationship is generally consistent with the toxicology of these compounds in laboratory mammals.

CONCLUSIONS AND FUTURE DIRECTIONS:

Community support has been received for two major collections in 1992. Walruses will be sampled at Igloolik (and possibly Hall Beach) in Foxe Basin, starting in May and ending in December. We anticipate 60-80 walrus samples. Ringed seals will be sampled at Pangnirtung starting in July and ending in March. We anticipate that this collection will continue in 1993 to provide about 20 seal samples per month for a full year. All samples will be obtained from animals harvested as part of local subsistence hunts.

We have also entered discussions with CWS (Dr. I. Stirling) about collaborating on a ringed seal collection at Arviat. This would produce about 75 samples in the spring and 75 in the fall.

All marine mammal samples will be taken on dry ice and shipped to Winnipeg for enzymatic and other analyses. Tissues will be provided to several other projects within the Arctic Environmental Strategy.

Table 4. Beluga whale liver microsomal enzyme activities (nmol/mg P/min) with the sum of several PCB congeners (37, 81, 126, 169, 105, 114, 118, 156) in blubber of the same whales taken in Husky Lake (Mackenzie Delta, 1989).

Number	AHH	EROD	P450 (nmol/ mg prot)	Sum of PCB congeners (pg/g)
8903665	0.050	0.144	0.085	138702
8903666	0.183	0.803	0.135	160152
8903667	0.377	2.055	0.300	400276
8903668	0.160	0.848	0.081	172600
8903669	0.364	1.396	0.232	338928
8903670	0.059	0.113	0.081	72904
8903671	0.092	0.335	0.195	205399
8903672	0.066	0.276	0.119	78808
8903673	0.104	0.850	0.175	323633
8903676	0.177	0.485	0.097	103475
8903677	0.493	1.885	0.199	487264
8903678	0.307	1.579	0.196	412813
8903679	0.395	1.467	0.228	519952

RESOURCES: (received in 1991/92, 1992/93 and planned under Green Plan AES)

	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
O&M ($K)	74	96	120	100	100	20

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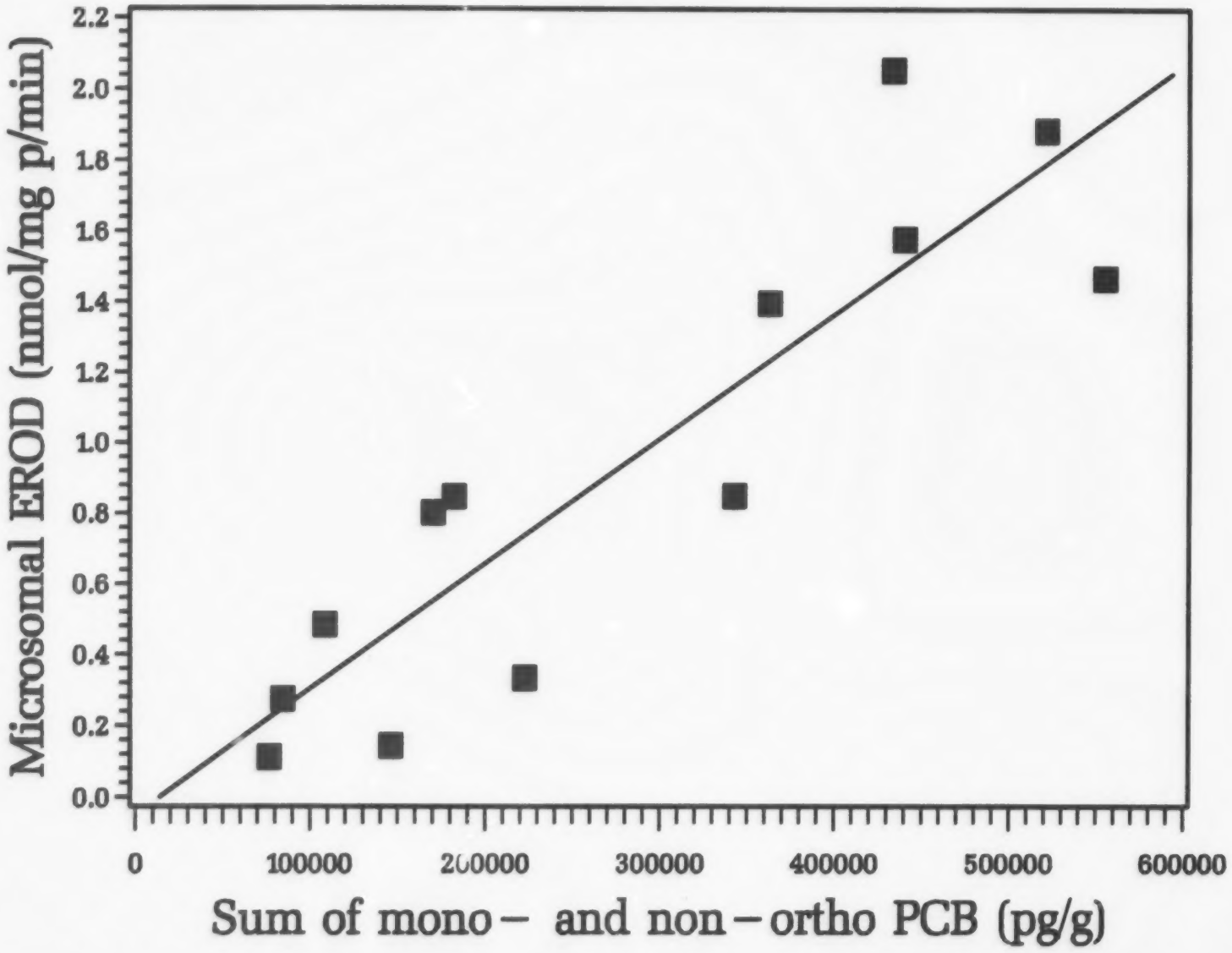
Figure 1, M & F, n = 3 – 42

Fig. 2. EROD activities in Mackenzie Delta beluga whales with differing mono – ortho and non – ortho PCB residues



BIOCHEMICAL STRESS INDICATORS IN FISH FROM NORTHERN LAKES

PROGRAM LEADER: W.L. Lockhart, Fisheries and Oceans Canada

PROJECT TEAM: D.A. Metner, R.W. Danell, D. Kenny

OBJECTIVES:

Short term: To obtain and analyze samples of arctic freshwater (and some marine) fish for analyses of biomarkers responsive to PCBs, chlorinated dioxins/furans, and PAHs, specifically liver microsomal mixed function oxidase enzyme activities.

Long term: To map arctic populations of freshwater (and marine) fish for current levels of biomarkers, and to test those levels for any relationships to contaminant measures in the same fish, and in sediments from those sites for which contaminant input histories are determined. This permits the evaluation of contaminants in terms of biological implications for the fish themselves.

DESCRIPTION:

Previous studies have described induction of mixed function oxidase (MFO) enzyme activities in fish exposed experimentally to several contaminants including petroleum, PCBs, and chlorinated dioxins and furans (Walton *et al.*, 1977; Forlin and Lidman, 1981; Addison *et al.*, 1982; Hahn *et al.*, 1989; van der Wieden, 1990), contaminants which are all present in arctic ecosystems. Field studies in sites contaminated with these materials have confirmed the ability of mixed-function oxidases to detect exposure in natural populations (Payne, 1976; Rogers *et al.*, 1989). These MFO activities have been used to argue that quality problems reported with burbot and whitefish downstream from a source of petroleum seepage at Norman Wells were not, in fact, caused by the seepages (Lockhart *et al.*, 1987, 1989). Aside from the Mackenzie valley work, this project is the only effort to define normal ranges of these biochemical variables in fish from the Canadian Arctic (Lockhart and Metner, 1991; 1992; Lockhart *et al.*, 1992).

In addition to the MFO enzyme work, this project also examines mercury and other metals in the fish from the same lakes where cores have been taken to describe any relationships between mercury and other metals in the fish and their concentrations in the sediments or their fluxes to the sediments (Lockhart, 1992).

This project is divided into two parts, a field part which collects fish samples for this and other Arctic Environmental Strategy projects, and a laboratory part which examines the fish collected for biological variables, for some contaminant levels (mercury), and for activities of cytochrome-P-450-related liver microsomal enzymes.

a) Field collections: During 1991/92 the field part consisted of organizing and conducting two field expeditions. The first was to Buchanan Lake on Axel Heiberg Island, N.W.T., in May, 1991. This expedition consisted of four full-time DFO personnel from Winnipeg and one part-time DFO employee from Resolute Bay. The expedition was assisted by aircraft time and ground equipment supplied by the Polar Continental Shelf Program, and was run from the Atmospheric Environment Service station at Eureka. The second field expedition to Lakes Laberge and Kusawa in the Yukon Territory was just recently completed (March 20, 1992). In this instance the expedition consisted of four DFO personnel from Winnipeg, with local assistance in Whitehorse from Environment Canada and Indian Affairs and Northern Development. In both instances the objectives were to collect fish for several projects and cores for the lake sediment project. Fish catches were suitable from Lakes Buchanan and Laberge, but poor from Lake Kusawa.

b) Laboratory analyses: Analytical work has focused on conducting the analyses of the fish from Buchanan Lake, and on fish from other sources obtained for comparative purposes. Also, during the year consistent problems with the fluorometer were finally solved with the ordering (on lease) of a new fluorometer. The analyses reported conducted are for two cytochrome-P-450-related catalytic activities, ethoxyresorufin-O-deethylase (EROD), and aryl hydrocarbon hydroxylase (AHH); cytochrome P-450 levels were also calculated and difference spectra for all samples were recorded. In addition, in cooperation with R. Hunt's laboratory, several heavy metals were measured in muscle tissue of most of the fish.

RESULTS:

A sample tabulation of mean values for arctic char is given below in Table 1 listing mean body size measurements for length, weight, gonad weight, and the three biochemical measures, EROD, AHH and cytochrome P-450. These data, taken alone, are difficult to interpret. It is only in the context of other similar data from other collections that patterns may become evident. The other linkages of these data are to other measures applied to the same fish or to sediments from the same lakes in other projects in the Arctic Environmental Strategy and beyond. For example, the Buchanan Lake sediments are high in PAHs, probably derived from coal - higher in fact than the sediments from Lake Hazen reported last year. Yet the fish show no evidence of enzyme induction. Indeed, examination of the gut contents of one fish revealed nothing but small granules of coal, and even this fish did not show enhanced enzyme activity. Apparently the PAHs in coal are not readily available to the char, even when the coal particles are consumed directly.

Table 1. Body size and MFO enzyme activities in arctic char from Buchanan Lake, N.W.T., May 1991.

FEMALES	Variable	Mean	Std Dev
	LENGTH	490	97.8
	WEIGHT	1124	603
	GONAD WEIGHT	19.0	18.4
	EROD	0.015	0.0106
	AHH	0.042	0.0230
	P450	0.106	0.0288
MALES	Variable	Mean	Std Dev
	LENGTH	586	136
	WEIGHT	1942	1010
	GONAD WEIGHT	14.9	19.5
	EROD	0.011	0.0037
	AHH	0.033	0.0092
	P450	0.143	0.0436

Through this and other programs we have now obtained three general north/south transects of these enzyme activities, one with lake trout and char (*Salvelinus*, shown in Figure 1), one with burbot, and one with whitefishes. These are all shown as maps (Figures 1-3). We have obtained recognizably high levels in whitefishes from some locations in southern British Columbia, but otherwise levels are mostly low and relatively uniform. The locations in southern British Columbia where high values were found were all downstream from discharges of bleached kraft pulp mill effluent. This is not to say that contaminants are not having any effects on fish in the Arctic, but it does suggest that effects are similar across the ranges of all three transects. Recent analysis of mono-ortho PCBs in burbot from several of the locations have shown statistical associations between residues of these congeners and EROD and AHH activities from the same individual fish. As more of these congener-specific analyses become available we will be able to test for these associations in other species and locations.

FUTURE DIRECTIONS: Field work for 1992/93 is expected to include a return to Lake Kusawa to obtain additional fish specimens and a winter expedition to the north/central N.W.T. mainland, tentatively to Lac Belot. A summer expedition to both these lakes is also planned to obtain soil profiles from the watershed to allow independent calculation of atmospheric inputs to the lake surfaces, and hence allow improved estimation of within-lake sediment focusing. In conjunction with U.S. EPA scientists, we will attempt to produce bathymetric maps of both lakes.

The new fluorometer should be operational within the first month of 1992/93, and this should improve the performance of the EROD assay. Work in the laboratory for the coming year will focus on the

analyses of fish collected in March, 1992, from Lake Kusawa, Yukon Territory, for the enzyme analyses and any other fish that may become available. As more data from other projects become available (sediment core profiles, organochlorine residues), more time will be spent in testing for linkages to the sediment program and to organochlorine residues. Studies of mercury and other heavy metals will be continued on the Lake Kusawa samples.

RESOURCES: ($K planned under Green Plan AES)

1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
0	0	100*	100	100	20

*includes $30 K capital in 1993/94

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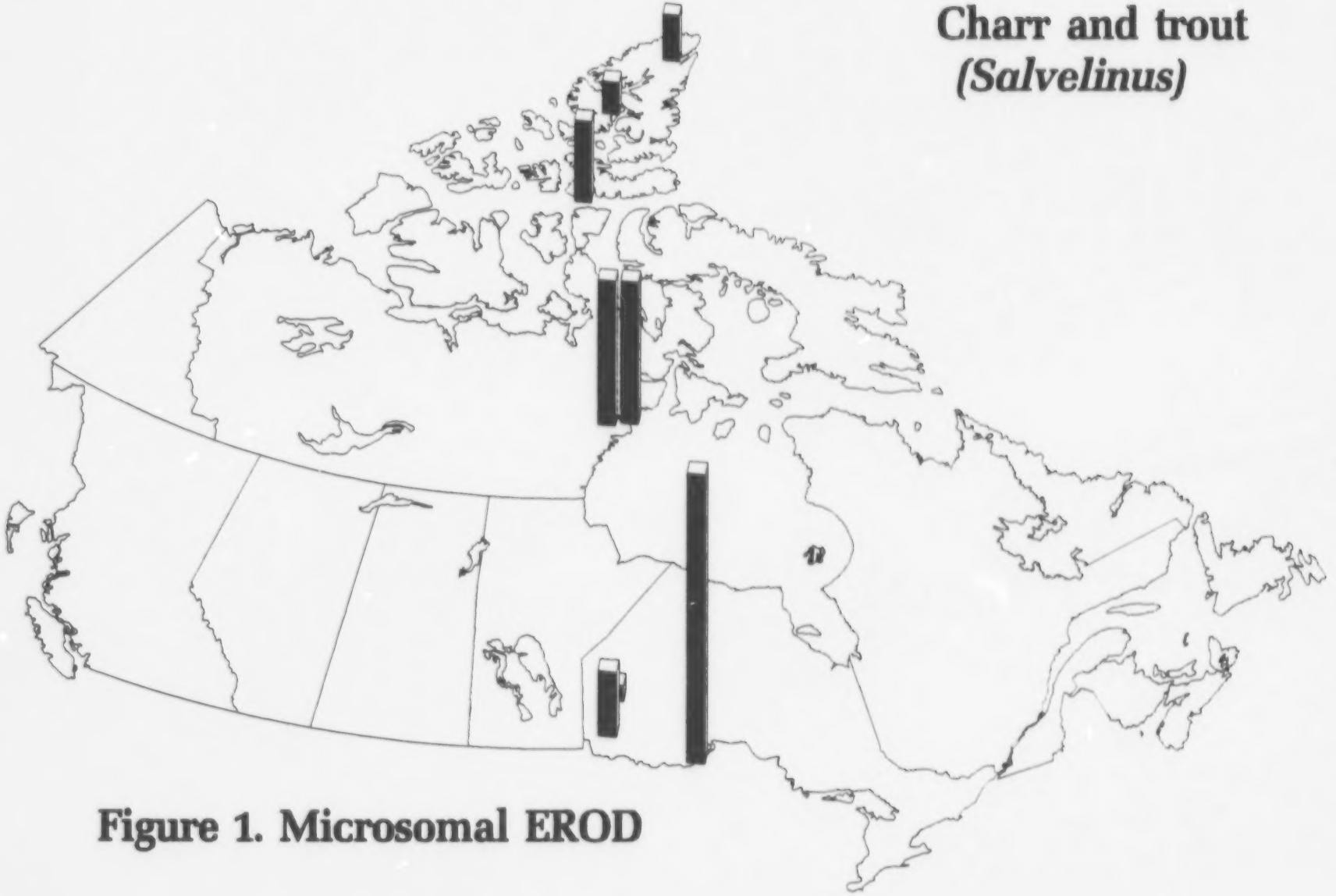

Figure 1. Microsomal EROD

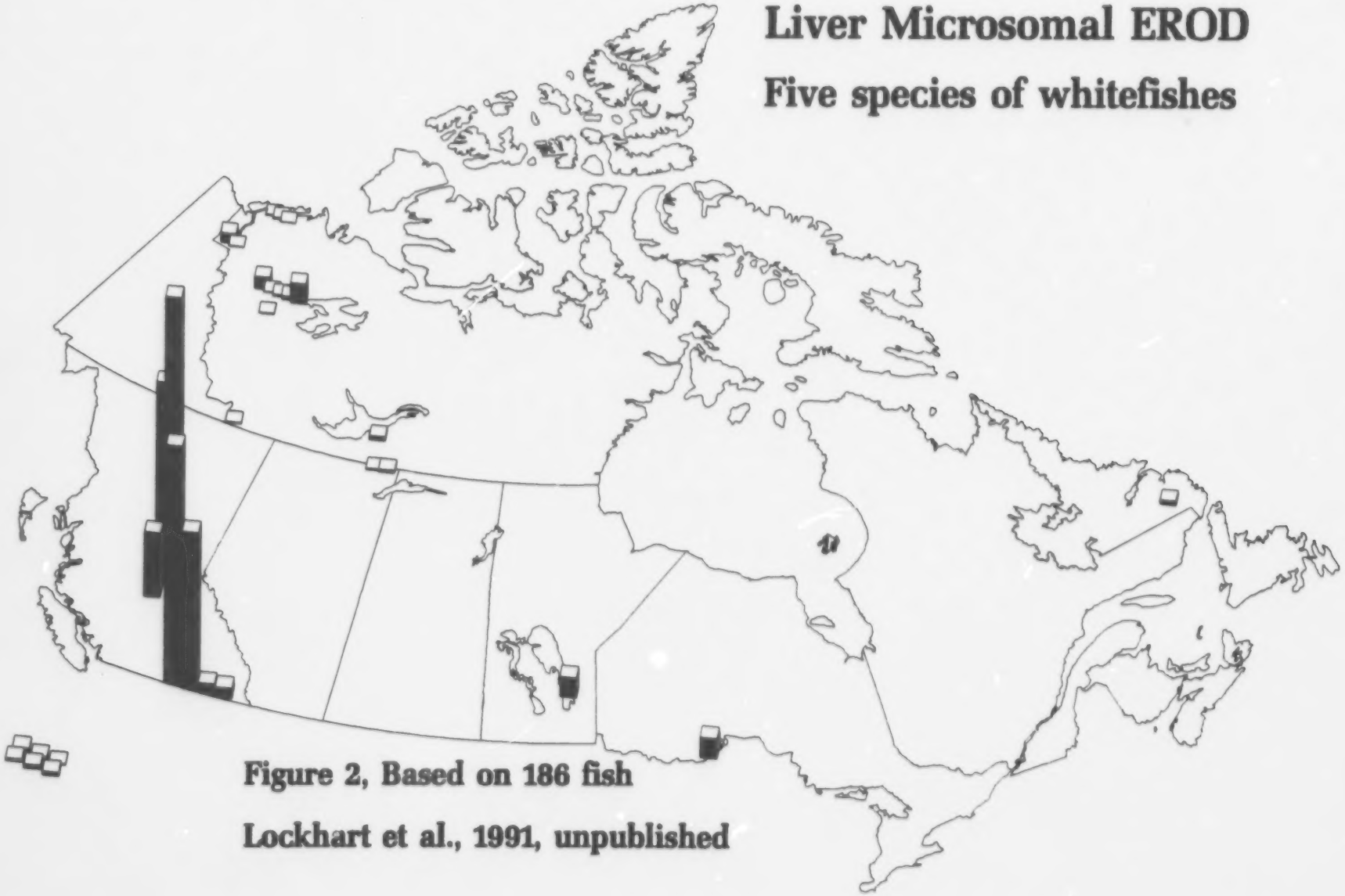

Figure 2, Based on 186 fish

Lockhart et al., 1991, unpublished

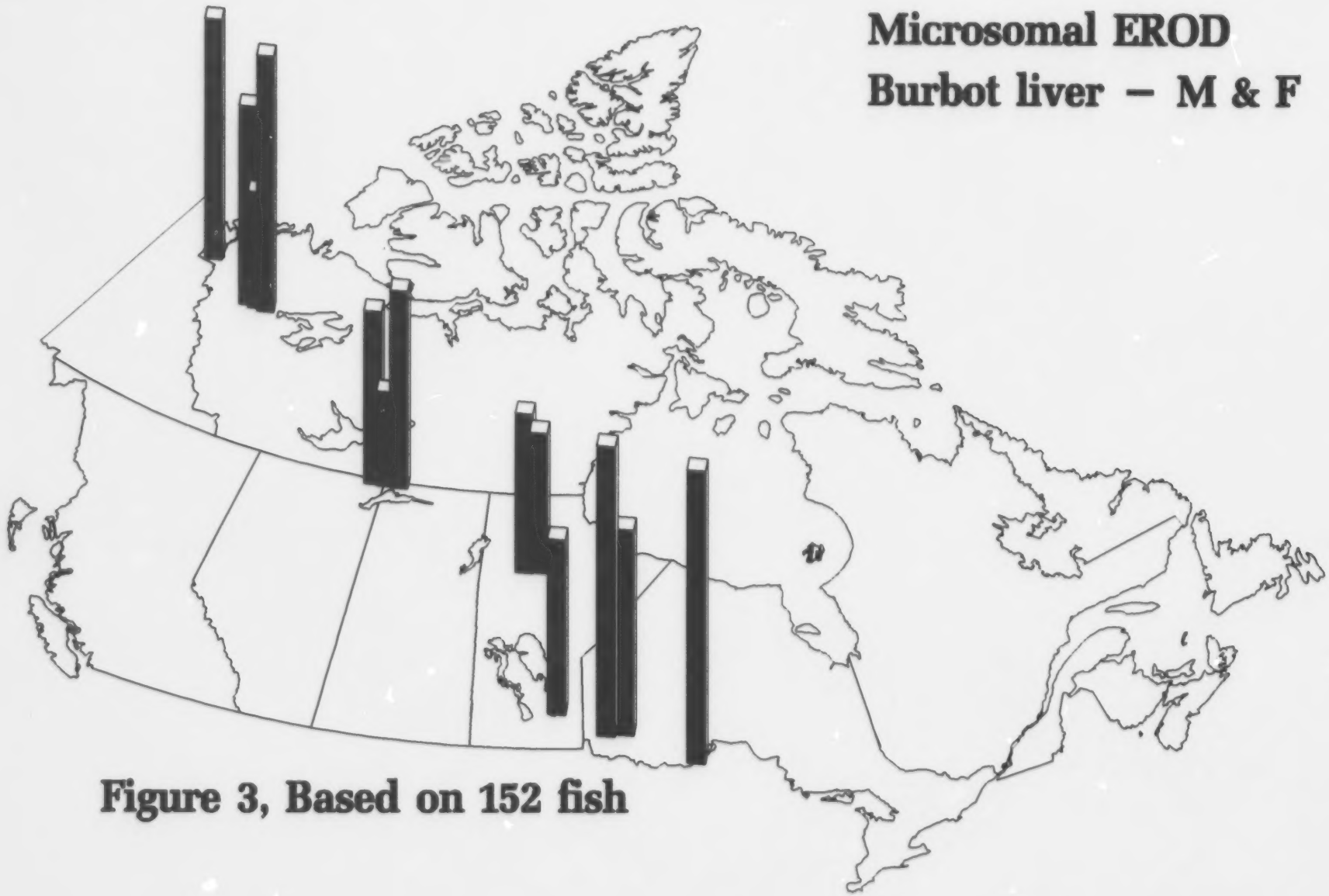

Figure 3, Based on 152 fish

FOOD CHAIN ACCUMULATION AND BIOCHEMICAL EFFECTS OF ORGANOCHLORINE CONTAMINANTS IN FISH FROM LAKE LABERGE AND OTHER YUKON LAKES.

PROGRAM LEADERS: D. Muir, W.L. Lockhart, Fisheries and Oceans Canada

PROJECT TEAM: D. Muir, B. Grift, D. Metner, B. Billeck, P. Wilkinson, W.L. Lockhart, B. Rosenberg (contractor)

OBJECTIVES:

1. Measure biochemical stress indicators (e.g. mixed function oxidase enzyme activity and hydroxyproline in bone collagen) and concentrations of organochlorine contaminants (DDT group, toxaphene, PCBs) in tissues of burbot, lake trout and whitefish from Lake Laberge.

2. Determine temporal trends in organochlorines via retrospective analysis of archived fish and dated sediment cores (see Project B.1.).

3. Determine food chain accumulation of selected organochlorines in Lake Laberge by sampling, analysis and characterization of important lower food chain organisms.

DESCRIPTION:

During 1990/91, samples of burbot liver, as well as muscle of lake trout and whitefish from Lake Laberge were shown to contain high levels of organochlorine pesticide levels. Concentrations of DDT group, toxaphene and PCBs in Lake Laberge fish exceeded levels in the same species from NWT by 4 to greater than 10-times and pointed to local sources of contamination. The lower DDE/ΣDDT ratio suggests a more recent source of 4,4'-DDT.

The elevated levels of toxaphene, DDT and, to a lesser extent PCBs, suggest that there could be biological effects of these chemicals on fish populations in the lake, such as reproductive failure, similar to those observed in the Great Lakes. Studies by Merhle *et al.* (1978) have shown associations between toxaphene and changes to the mechanical strength and biochemistry of bone, specifically the amount of amino acid hydroxyproline, in rainbow trout. Mono-ortho and non-ortho substituted PCBs are known to induce mixed function oxidase (MFO) enzyme systems in fish and mammals.

Biomarkers for toxaphene (hydroxyproline) and PCBs (MFO) will be determined in fish bone and liver, respectively, freshly collected from Lake Laberge. Fish from other lakes in the Yukon, and from our "Biochemical Stress Indicators" program in the Arctic Environmental Strategy, will serve as controls. Fishes will be fully characterised as to age, size and sex.

Muscle from fish analyzed for biomarkers will also be analyzed for

organochlorine contaminants and for co-planar PCBs. Samples of whitefish from Lake Laberge collected in 1974 will be retrieved from DFO freezers - they were originally collected by Dr. Jim Clayton for studies on population genetics - and analyzed for organochlorines to examine temporal trends in the contaminant levels. Results of retrospective analysis of archived fish and of dated sediment cores for toxaphene, DDT compounds and PCBs will be used to address the question of local versus long range transport sources and temporal trends in contaminant levels.

Sediment dwelling invertebrates and forage fish, which form the food chain to piscivorous fish such as lake trout and burbot in Lake Laberge, will be collected for organochlorine analysis. This food chain study will investigate whether food chain length and structure may partly explain high levels of organochlorine contaminants in the piscivorous fish. It is anticipated that this study will be conducted in collaboration with a Ph.D. student working out of University of Alberta (Zoology). Analyses will be conducted at DFO Winnipeg.

ACTIVITIES IN 1991/92:

(a) **Sample collection:** Fish and sediment cores were collected March 10-22, 1992, from Lake Laberge and Kusawa Lake (control site) by DFO personnel (D. Metner, P. Wilkinson, B. Billeck, R. Danell) assisted by Ph.D. student K. Weresak (Univ. Alberta) in cooperation with Yukon DOE, DFO, and YKG biologists.

(b) **Retrospective analysis of fish:** Whitefish from Lake Laberge collected in 1974 were retrieved from DFO freezers. They had been stored intact in polyethylene bags at -20 to -40°C for 18 years. Weight, length and sex of the fish were recorded. Ootoliths were taken for aging. Muscle samples were taken for analysis of toxaphene, total DDT (ΣDDT) compounds and total PCBs (ΣPCB). Extraction, lipid removal, and chromatographic cleanup and GC analysis followed methods described by Muir *et al.* 1990.

(c) **Quality assurance:** Homogenates of burbot liver from Atlin Lake were prepared by Axys Labs (Sidney, BC) and subsamples were analyzed in our labs. Routine internal quality control steps were identical to those outlined in "Contaminant Trends in Freshwater Biota".

RESULTS:

(a) **Sample collection:** The March field trip successfully accomplished all major sampling objectives for 1992. Lake trout and whitefish were collected in Lake Laberge, and at the control site, Kusawa Lake. However, only a limited number of liver samples for MFO assays were obtained from lake trout in Lake Laberge because fish had died by the time the samples were retrieved. Analysis of the samples for biomarkers (MFO P4501A1 enzyme induction, hydroxyproline levels) will begin in April. Additional sampling for food chain related organisms has been proposed by D. Schindler and K. Weresak (separate proposal submitted) during the summer of 1992. A followup study for additional

fish and food chain organisms may be required in spring of 1993.

(B) **Retrospective analysis:** Elevated concentrations of ΣDDT related compounds (2,4'- and 4,4'DDE, 2,4'- and 4,4'-DDD, 2,4'- and 4,4'-DDT) were found in six whitefish muscle samples collected in Lake Laberge in 1974 (Table 1). Omitting one extremely high level (1730 ng/g wet wt) mean concentrations of ΣDDT averaged 222 ng/g which is very similar to levels in 3 composite samples of whitefish muscle (total 23 fish) collected in fall of 1990 (Table 1). But the single high result suggests the possibility of elevated DDT contamination in the past. The low ratio of DDE/ΣDDT in the 1974 whitefish than those from 1990 is a further indication of a recent DDT source contaminating the water and food chain.

High levels of 2,4'- and 4,4'-DDD were found in whitefish indicating reductive dechlorination of DDT occurred during storage. This degradation was expected over the 18 year period and it has implications for other chlorinated aliphatic compounds such as toxaphene and HCH.

Toxaphene and ΣPCB levels in whitefish from 1974 were similar to present day levels (Table 1). The pattern of chlorinated camphene peaks appeared similar to other fish we have analyzed, but the possibility of some dechlorination during storage must be considered.

Although toxaphene and ΣPCB concentrations were low in 1974 and 1990 whitefish, consistent with lower biomagnification of these compounds in detritivorous fishes, these levels are 8 and 42 times higher, respectively, than found in broad whitefish from the Tuktoyaktuk region, when compared on a lipid basis (Table 1). Toxaphene and ΣPCB in lake whitefish from Fisherman Lake (NWT) were 5 and 3-times lower than in Lake Laberge. Lipid weight comparison was performed to take into account differences in lipid content between locations.

(c) **Interlab comparison:** There was good agreement between the two laboratories on toxaphene, total chlordane (ΣCHLOR) and HCB (within 10%), and reasonable agreement for HCH, PCBs and ΣDDT (25-31%) but poor agreement on dieldrin (Table 2). Geometric means were used to permit comparison with Mackenzie River burbot where wide ranges of concentrations of organochlorines were found.

The toxaphene levels in Atlin Lake burbot liver are elevated in comparison with the same species from the Dawson area and from the Mackenzie River (Table 2). Localized contamination appears to be the only obvious explanation because levels of ΣDDT and PCBs in these samples do not differ greatly from "background" levels i.e. from the range of results in burbot liver samples from Dawson City and the Mackenzie River locations.

CONCLUSIONS AND UTILIZATION OF RESULTS:

Retrospective analysis of whitefish collected in 1974 show that they have levels of ΣDDT which (for 5 or 6 fish) are within the range observed for 3 composite samples collected in the fall of 1990. Levels

of toxaphene and ΣPCB are remarkably similar to 1990 levels although it is possible that some degradation of the former compound could occur on storage. For 1992-93 more whitefish will be analyzed to try to fully characterize the range of concentrations observed in the retrospective samples.

In 1992/93, analyses for mixed function oxidase enzyme induction and hydroxyproline as well organochlorine contaminants will be carried out on samples collected in March 1992. The contaminants data will be supplied to NH&W for evaluation of human health risk. Depending on the results of biomarker and contaminant analyses, further sampling may be required. The results will allow firmer conclusions to be drawn concerning possible impacts of elevated concentrations on fish populations and on the question of temporal trends in contamination.

Expected project completion date: March 31, 1994.

Partners: The project has been designed and carried out with the collaboration of J. Eamer (DOE Whitehorse), K. Simpson (DIAND) and A. Von Finster (DFO Yukon). Dr. Dave Schindler (University of Alberta, Zoology Dept.) will collaborate on the food chain studies.

RESOURCES: (received in 1991/92, 1992/93 and planned under Green Plan AES)

	1991/92	1992/93	1993/94
Total ($K)	25	52	40

Table 1. Mean concentrations (ng/g ± SD) of organochlorines in Lake Laberge whitefish compared with levels in the same species from N.W.T. locations

Location	Sex	N	ΣHCH	ΣCHLOR	ΣDDT	ΣPCB	PCC[1]	DDE/ΣDDT
A. Wet weight basis								
Lake Laberge 1974	M	6	9.6±2.5	5.3±3.4	470±620	65±51	21±13	0.55
(omitting high result)		5	9.7±2.8	4.0±1.3	222±65	45±21	16±7	0.54
Lake Laberge 1990[1]	?	3	<2	7.9±4.6	211±111	61±21	31±23	0.62
B. Lipid weight basis								
Lake Laberge 1974	M	6	250±56	140±110	13300±19000	1760±1600	566±408	
Lake Laberge 1990[1]	?	3	<60	330±260	7630±4120	2340±1290	1250±1180	
Canyanek Creek	F	6	29±7		30±10	13±6	44±52	119±59
(Tuktoyaktuk)	M	4	31±10	27±11	13±9	38±6	100±30	
Fisherman Lake (Fort Simpson)	M+F	4	70±21	43±26	31±6	672±122	190±43	

Table 2. Comparison of organochlorine levels in burbot liver from Atlin Lake analysed by DFO Winnipeg and by Axys Labs (Sidney BC) and with previous results from the Mackenzie River and Dawson City.

Location	Geometric means (ng/g lipid wt basis)							
	N	ΣPCB	ΣDDT	ΣCHLOR	ΣHCH	dieldrin	HCB	PCC[1]
Fort Good Hope[2]	11	400	180	330	51	18	45	580, 820
Slave River[2]	5	430	170	320	29	23	45	1000, 1430
Dawson City[3]	3	200	180	88	18	6	28	200, 290
Lake Laberge[3]	6	1330	3350	293	65	21	43	2010, 2900
Atlin Lake - DFO	6	530	210	450	130	55	48	2830
Atlin Lake - Axys[4]	6	400	300	430	190	28	45	3122

[1] Toxaphene quantified with multiple response factors (left hand number) or a single response factor (right hand number). The single response factor method was used by Axys Analytical Labs.
[2] Muir et al. Unpublished results, 1989.
[3] Muir et al. Report to DIAND and DOE Yukon, 1991.
[4] Results from a report by Axys Analytical Services Ltd. to DIAND, Dec. 1991.

IDENTIFICATION OF BASELINE LEVELS AND REPRODUCTIVE EFFECTS OF ORGANOCHLORINE AND HEAVY METAL CONTAMINANTS IN MINK (*Mustela vison*)

PROGRAM LEADERS: B. Elkin and K. Poole, Department of Renewable Resources, Government of Northwest Territories

PROJECT PARTNER: D. Haffner, Great Lakes Institute, Windsor

OBJECTIVES:

1. To assess the exposure of wild mink to organochlorine and heavy metal contaminants.
2. To determine baseline levels of organochlorine and heavy metal contaminants in several mink tissues.
3. To identify geographical trends of these contaminants in mink along the Mackenzie River system.
4. To provide baseline contaminant data that will serve as the basis for ongoing monitoring of temporal trends in mink.
5. To evaluate the potential biological effects of organochlorine contaminants on mink reproduction.
6. To evaluate mink as a sensitive indicator species to monitor the effects of environmental contaminants on ecosystem health.

DESCRIPTION:

Very little information is available on the contaminant load in terrestrial wildlife in the Canadian Arctic. The limited amount of residue information does not allow for any speculation on the presence or trends of specific contaminants in terrestrial wildlife, and the scarcity of metal or organic residue data for terrestrial mammals has been identified as one of the major data gaps in arctic contaminant research. The limited analyses that have been conducted on terrestrial species have indicated that a variety of contaminants are present, and warrant more comprehensive studies to establish baseline levels.

Fish-eating furbearers are a top trophic level species that readily bioaccumulate environmental pollutants such as PCB's, DDT and methylmercury due to their piscivorous nature. Mink (*Mustela vison*) are extremely vulnerable to organochlorine contaminants, and are known to experience reproductive failure as a result of eating fish contaminated with PCB's. Dietary doses of PCB's as low as 0.64 ppm fed for 160 days can result in nearly complete

reproductive failure. This unique susceptibility can result in population effects at low levels of environmental contaminants. As such, mink may provide a sensitive indicator to assess short and long term trends in environmental contaminants and ecosystem health.

A number of organochlorine and heavy metal contaminants have been identified in freshwater fish in the Mackenzie River, providing a potential source of contaminants for fish-eating furbearers. Studies on fish at Ft. Good Hope and Colville Lake have detected the presence of PCB's, toxaphene and chlordane, as well as HCH, chlorobenzene, dieldrin and DDT. The heavy metals copper, nickel, cadmium, mercury, selenium and zinc have also been identified.

This study will evaluate the presence and establish baseline levels of organochlorine and heavy metal contaminants in mink along the Mackenzie River. The study will examine geographical variations in contaminant levels along the river system, as well as a reference site located off the river system. The baseline values established may identify specific contaminants that warrant further study, and provide the basis for a more specific ongoing monitoring program. The baseline data established in the initial component of this study will the be used in an evaluation of the potential biological effects of organochlorine contaminants on mink reproduction.

ACTIVITIES:

This project was initiated in the fall of 1991, with AES Contaminants Program funding allocated in October 1991. The project is comprised of two major components. The initial phase is a three-year study to establish the type and baseline levels of contaminants present in mink along the Mackenzie River system. Based on the results of Phase I, the second phase will examine the physiological impact of the contaminants on reproduction and population levels.

The objectives and outline of the study were presented to local Hunter's and Trapper's Associations in the study communities. Several radio interviews and announcements have been made addressing the study, and an information article on the study appeared in the Trappers News. Local trappers were identified to participate in the study, and have played an integral part in completion of the field collections.

Sample collection

Mink are being collected from four sites in the NWT. North-south variations in contaminant levels in mink along the Mackenzie River will be evaluated through collections at Fort Simpson, Fort Good Hope and Inuvik. Fort Rae is being used as a control site located off of the Mackenzie River. Samples were collected from all four communities in 1991/92, and samples will be collected from Inuvik in two subsequent years to evaluate short term temporal trends.

Whole mink carcasses are purchased from local trappers throughout the trapping season, shipped to the project leaders for sample preparation, and forwarded to the appropriate analytical laboratories. Twenty mink are collected from each site, with an even distribution by age and sex. Liver, kidney, fat and hair samples are collected from each animal for contaminant analysis. Teeth are collected for aging, and stomach contents are collected for diet composition analysis. A variety of reproductive, biological and morphometric measurements are also recorded.

Analysis

The study will initially involve broad-spectrum screening for organochlorine and heavy metal contaminants. Organochlorine analysis will be conducted on both fat and liver samples in order to evaluate tissue distribution resulting from considerable seasonal body fat fluctuations in mink. Selected samples will be analyzed for co-planar PCB's and dioxins/furans. Heavy metal analysis will be run on liver, kidney and hair samples. Hair will be evaluated as a potential sampling method in living animals.

In 1991/92, tissue samples from 60 mink collected at 3 study sites were forwarded to the Great Lakes Institute for contaminant analyses. Twenty samples collected in 1991/92 were frozen and stored for analysis in 1992/93. Sample analysis is currently being completed, and final results are not yet available. However, initial results have indicated the presence of significant levels of PCB mixture 1260 in a number of samples.

RESULTS AND FUTURE DIRECTIONS:

The 1991/92 field collections were completed on schedule, and contaminant analyses are currently underway. Preliminary results have indicated the presence of significant levels of PCB mixture 1260 in a number of samples. Complete results are expected in early 1992/93.
1992/93 will be the second complete year of the study. Mink will continue to be collected from Inuvik, and samples from 20 mink will be analyzed in addition to 20 stored samples collected in 1991/92. Pending final results from Year 1, further sampling may also be done at the other study locations if the initial results warrant.

Expected project completion date: Phase I of the project on the baseline contaminant levels and spatial/temporal trends will be completed at the end of 1993/94. Phase II examining the physiological impact of the contaminants on reproduction and population levels will occur from 1994/95 to 1996/97.

RESOURCES EXPENDED: ($K) (1991/92)

AES - Contaminants Program	
Contract Services	70.2
Supplies/Services	7.8
Travel/Transport	2.0
	80.0
GNWT-DRR A-Base	
PY's	0.3
Salary	15.0
O&M	5.0
	20.0

INTERLABORATORY QUALITY ASSURANCE PROGRAM FOR THE NORTHERN CONTAMINANTS RESEARCH PROGRAM

PROGRAM LEADERS: Quality assurance steering committee, D. Muir (acting chair), Fisheries and Oceans Canada

OBJECTIVES:

1. Develop an interlaboratory quality assurance (QA) program for the determination of organochlorines (i.e. PCBs, DDT, toxaphene etc), metals (Pb, Hg, Cd) and polyaromatic hydrocarbons (PAHs, i.e. naphthalene, B(a)P) in arctic samples by various projects under the AES.

2. Ensure acceptable levels of accuracy and precision of all analytical results reported by participating laboratories.

DESCRIPTION:

Analytical data of high quality are required for the Northern Contaminants program because the data are to be used to assess human health impacts, to assess temporal trends and sources and to contribute to international initiatives. There is a need for interlab programs to ensure that comparability of results exists among labs for the wide range of chemicals being determined.

The Quality Assurance program will probably consist of three components, an initial survey, an interlab comparison with appropriate QC samples, and development of QC guidelines. The survey or questionnaire will help identify all participating labs, the analytes they are measuring for the Northern Contaminants Program, the interlab programs they are currently participating in, and routine intralab QC steps (eg. use of internal standards, analysis of replicates, analysis of Standard Reference Materials (SRMs)). All labs funded directly via the AES, or indirectly via contract to an AES participant, would be required to respond to the survey, and participate in subsequent interlab studies, as a condition of receiving funding.

The interlaboratory QA program will involve the preparation and circulation of "blind" environmental samples of special interest in the Northern Contaminants program. Participating labs will be asked to select from several sample matrices depending on their field of interest. It is likely that pooled, bulk samples of sediment, fish and marine mammal tissues (e.g. blubber for organochlorines and liver or kidney for metals) and possibly plant material could be prepared by a contractor. The program may also include an initiative to circulate analytical standards and/or standard reference materials for a few specific types of matrices along with a set of QC guidelines that each laboratory could follow voluntarily.

The guidelines would be prepared by the contractor in consultation with the Quality Assurance steering committee. It should be possible to draw heavily on existing QA/QC guidelines for e.g. "The CWS Guideline to Practical Quality Assurance for Contracted Chemical Analysis".

The circulation of pooled QC samples would begin in mid 1992/93 and be repeated annually. The results of the analysis of these samples would be analyzed statistically by the contractor and reported at annual reviews of the Northern Contaminants program. The report would provide a measure of the quality of the analytical data being produced by the entire program, it would rank the labs (coded for confidentiality) and flag those who produce unacceptable results.

ACTIVITIES IN 1991/92:

An introductory protocol was prepared which outlined the basic design of an interlaboratory program. The protocol was circulated to scientists with DFO (J. Uthe, H. Rogers), DOE (H. Vaughan, R. Norstrom) and NH&W (H. Schwartz, H. Newsome) for comment. Comments were received from everyone. Several of the reviewers referred to existing QA/QC guidelines, e.g. from Association of Official Analytical Chemists, Canadian Wildlife Service, the International Standardizing Organization, and National Water Research Institute.

CONCLUSIONS AND UTILIZATION OF RESULTS:

Comments were generally supportive of the directions outlined in the protocol. There was concern that a survey of labs might not yield useful information unless care was taken to indicate precisely what was wanted in response to each question. Several reviewers were concerned that the interlab program would not measure the accuracy and precision of routine analyses conducted in each lab. Demonstration of good intralaboratory QC was judged more important than performance on an interlab sample.

For 1992/93 the Steering Committee consisting of representatives of DFO, CWS, IWD, AES and NH&W, will be formed to oversee the program and let a contract (pending Science Manager's approval). The protocol will be revised to reflect comments from reviewers and input from the steering committee. The draft protocol will then be formulated as a Statement of Work for the contract. It is hoped to have a contractor in place by September and to begin initial interlab comparisons by December '92.

RESOURCES*: (received in 1992/93 and planned under Green Plan AES)

	1992/93	1993/94	1994/95	1995/96	1996/97
Selection of contractor	4	-	-	-	-
Contractor salary (assumes 0.5PY)	24	30	30	30	30
Phase I - survey	4	-	-	-	-
Phase II - QC samples, standards and SRMs	12	15	15	15	15
Reports/Guidelines/contingencies	4	5	5	5	5
Total ($K)	48	50	50	50	50

* Costs for this project are very tentative. All work is intended to be contracted out to an experience analytical laboratory. The 0.5 PY is listed to indicate the approximate Person Years required to do the work.

HUMAN HEALTH

HUMAN HEALTH
OVERVIEW

Recent Findings

1) Contaminants data for humans and various animal species have been compiled in a computerized database. Data is available for the Yukon and Northwest Territories, Labrador, Greenland, and the hydrographic basins of Hudson and James Bay.

2) Estimated daily intake of PCB #153, DDE, and dieldrin are 2, 2.5 and 5 times greater, respectively, in Inuit of Broughton Island than in those of northern Quebec communities.

Knowledge Gaps

1) Scientific knowledge is currently inadequate to address the potential long-term adverse human health effects associated with exposure to organochlorine contaminants.

2) There is a need for human biomarker/bioindicator data to enable the early detection of long-term chronic effects.

3) A more detailed assessment of the human health risks and benefits associated with the consumption of northern food resources contaminated by organochlorines throughout the Territories is needed.

Future Work

1) A study will be undertaken to determine the relationship between the harvest (number of animals killed), the traditional food consumed by Northerners and the baseline levels of contaminants found in these foods. This linkage will provide the basis for a more specific ongoing monitoring program that will be used to provide information to the public with respect to possible health risks associated with consuming these foods.

2) A health risk assessment will be conducted during 1992/93 for breast-fed newborns from communities in northern Quebec exposed to organochlorine contaminants through the aquatic food chain. Results of this assessment will be used to orient future epidemiological studies to specific adverse health effects and eventually to provide public health recommendations regarding the traditional diet.

3) The level of human exposure to persistent organic pollutants will be characterized by analyzing samples of human blood (including blood of pregnant mothers and the umbilical cord). Organochlorine exposure of fetuses will be assessed through cord

blood studies and neurobehavioural studies of infants exposed in-utero to organochlorines.

4) A profile of contamination in humans will be established for organochlorines and heavy metals in sample communities representative of the population in Northern Quebec. The risk of cancer related to such contamination will be calculated and this calculation will be validated with information on the rate of cancer. A comprehensive analysis of the risks and benefits of consuming marine products will be carried out and recommendations will be made for the population, and the regional, provincial and federal governments.

5) Concerns of Yukon native communities will be identified, and an appropriate action plan will be developed to respond to the environmental issues which may impact these communities, including the contamination of traditional foods.

6) Dietary methodology, necessary to obtain sufficient information for nutrition and contaminant evaluation of Inuit populations with a minimum of community intrusion, will be refined.

7) Update of the contaminant database developed by E. Dewailly, Centre Hospitalier de l'Université Laval (CHUL), will be undertaken.

USE OF THE ARCTIC CONTAMINANT DATABASE TO ESTIMATE HUMAN EXPOSURE

PROGRAM LEADER: É. Dewailly, Community Health Department, Centre Hospitalier de l'Université Laval

PROJECT TEAM: P. Ayotte, H. Careau, É. Dewailly, A. Vézina

OBJECTIVES:

1. Estimate dietary intake of contaminants for native populations living in the Arctic.
2. Conduct health risk assessment associated with this dietary exposure.
3. Provide public health recommendations regarding the traditional diet.

DESCRIPTION:

Introduction

Arctic food chain contamination by metals and organochlorine compounds is of interest for the ecosystem in its entirety, including human populations which are located at the highest trophic level. We have obtained contamination data on humans and various animal species from various researchers and publications and compiled them in a computerized database. Data is available for the Yukon and Northwest Territories, Labrador, Greenland and the hydrographic basins of Hudson and James Bays. Fifteen contaminants were selected for integration in the first report of this project (Careau *et al.*, 1992), according to their persistence and their toxic potential for human health. We also focused on species and tissues of high dietary importance for the native populations. The development period is now completed and information is being updated as new data is made available.

Activities in 1991/92: Estimating daily intakes of contaminants

Levels of contaminants in the various food items can be extracted from the database and used in conjunction with dietary habit data for the purpose of estimating human exposure to the various contaminants. Alternatively, when data on contaminant levels in a human biological sample are available, daily doses can be estimated using pharmacokinetic models. This paper presents examples of both approaches to estimate exposure to selected organochlorine contaminants. The pharmacokinetic approach was applied to estimate daily contaminant doses for the Inuit population of Northern Québec (Hudson and Ungava regions), using contaminant levels measured in milk samples. For an Inuit population from Broughton Island

(Baffin region), daily intakes can be calculated using consumption rates for various traditional food items and the contamination data on these tissues compiled in the database.

The Broughton Island example

Dietary habits of the Inuit living on Broughton Island were studied by Kuhnlein (1989). Consumption rates of various food items derived from data on women reported in this study are presented in Table 1. Also shown in this table are the estimated daily intakes of dieldrin, Σ DDT and Σ PCBs. These were obtained by multiplying the consumption rate by the mean tissue contaminant level found in the database for the Baffin region.

Table 1. Broughton Island Inuit traditional diet (women) and estimated daily intake (DI) of organochlorine contaminants.

Species	Tissue	Intake (g/day)	Dieldrin DI (μg/day)	Σ DDT DI (μg/day)	Σ PCB DI (μg/day)
Ringed seal	muscle	260	0.52	5.36	8.53
	blubber	23	1.51	15.18	13.02
	liver	4	0.01	0.03	0.06
Bearded seal	muscle	10	0.002	0.08	0.12
Narwhal	muktuk	74	0.98	6.28	10.51
	muscle	22	0.48	6.49	5.28
	blubber	8	3.34	40.48	35.14
Beluga	muktuk	2	0.24	1.69	2.26
Walrus	muscle	24	0.18	0.53	1.49
	blubber	6	1.68	5.75	13.75
Arctic char	muscle	65	0.16	0.25	0.73
TOTAL		**498**	**9.1**	**82.1**	**90.9**

The calculated daily contaminant intakes in Table 1 are the values corresponding to the average consumption rate for women and average contamination data for the Baffin region. The average contaminant level is based on a limited number of samples and may not be representative of the tissues actually consumed. This method is also insensitive to yearly variation of dietary habits due to fluctuation of the availability of certain species.

The Northern Québec example

For the Northern Québec Inuit (from Hudson and Ungava regions), only limited data is available on their dietary habits. However, Dewailly (1991) reported on milk fat levels of PCBs and various organochlorine pesticides for 109 women from these regions. Breast milk samples were taken on the third day of breast-feeding. Assuming that milk fat concentrations are similar to adipose tissue concentrations and that equilibrium conditions are achieved between the body burden and the environment, the following equation can be used to estimate daily doses:

$$DI = \frac{C_{at} \times 0{,}693 \times W_{at}}{BW \times f_{bio} \times f_{at} \times t_{1/2}}$$

DI = daily dose (µg/kg/jour)
BW = body weight = 60 kg;
C_{at} = adipose tissue concentration (µg/kg);
W_{at} = adipose tissue weight = 13.6 kg (Shephard and Rode, 1974);
f_{bio} = bioavailability factor = 0.6;
f_{at} = fraction of the contaminant body burden present in adipose tissue = 0.85;
$t_{1/2}$ = half-life (days).

Since milk secretion is an efficient route of excretion for organochlorine compounds, equilibrium assumption, as stated above, is more likely met for the 33 women who did not breast-feed prior to this birth. Hence, the average contaminant levels for this subgroup were used to estimate daily doses. Table 2 presents the mean concentration, the estimated half-life from the literature and the estimated daily dose for dieldrin, DDE and PCB congener 153.

Table 2. Average milk fat concentration of organochlorine compounds for Northern-Québec Inuit women and estimated daily doses.

Contaminant	Concentration in milk fat (µg/kg)	Estimated half-life (days)	Daily dose (µg/kg/day)
Dieldrin	27	266	0.03
DDE	1319	730	0.56
PCB #153	386	730	0.16

Daily intakes for both Inuit communities are presented in Table 3. Estimated contaminant daily doses for the Broughton Island community are 2 to 5 times higher than those estimated for the Northern-Québec communities. This could be the result of differences in the amount of traditional food consumed by the communities and/or different contaminant levels in the tissues consumed. Dietary habits of the Northern-Québec communities have yet to be

studied extensively; significant differences are expected between the Broughton Island and Northern-Québec communities, the latter being located closer to southern industrialized regions.

CONCLUSIONS AND FUTURE DIRECTIONS:

Two methods have been presented that estimate exposure to contaminants present in traditional food items. In conducting a health risk assessment, internal dose measurements (blood or milk contaminant levels) are preferred to ingested doses for exposure estimation, since they integrate long-term exposure to organochlorine contaminants and avoid the known imprecisions associated with the use of a dietary questionnaire in the north. Data on dietary habits and animal tissue contamination are nevertheless important to determine which food items are major contaminant sources for human populations.

Plans for 1992/93 are to conduct a health risk assessment for breast-fed newborns from communities exposed to organochlorine contaminants through the aquatic food chain. Work has already begun on exposure assessment through the breast feeding period, using data from the newborn cohort study conducted in 1990/91. Results of this health risk assessment will be used to orient future epidemiological studies to specific adverse health effects and eventually to provide public health recommendations regarding the traditional diet. Contaminant database update is an on-going process.

Table 3: Daily doses of organochlorine compounds in two Inuit communities.

Contaminant	Daily doses (μg/kg/day)	
	Northern-Québec	Broughton Island*
Dieldrin	0.03	0.15
DDE**	0.56	1.4
PCB #153***	0.16	0.3

* Daily intakes from Table 1 were divided by a 60-kg body weight to obtain daily doses.

** Estimated daily dose of Σ DDT from Table 1 was assumed to represent essentially DDE exposure.

*** PCB #153 congener intake for Broughton Island was assumed to represent 20 % of total PCB congener concentration, as reported by Muir and coworkers (1988) for ringed seal blubber.

Partners: This work is being performed in collaboration with G. Carrier (Université de Montréal) for the toxicokinetic modelling and J.-P. Trépanier (Ministère de l'Environnement du Québec) for the exposure modelling and computer simulations.

RESOURCES:

Funding has been received under the Northern Contaminants Program for the newborn health risk assessment ($60 K for 1992/93).

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HUMAN CONTAMINANT TRENDS IN THE NORTHWEST TERRITORIES
HUMAN HEALTH BASELINE

PROGRAM LEADER AND SUPPORTING AGENCIES:

J.B. Walker, NWT Department of Health;
Government of the Northwest Territories (GNWT);
Health and Welfare Canada (HWC), Medical Services Branch,
Food Directorate, and Environmental Health Directorate

OBJECTIVES:

GNWT and HWC will be coordinating this study to develop and/or implement:

1. consultation programs/mechanisms related to contaminants and human health;

2. sampling protocols and collection strategies;

3. biomarker research in arctic populations;

4. analytical methodologies including QA/QC components;

5. tissue banking, including sample collection, preparation and storage, in addition to maintenance of a tissue banking facility;

6. analyses of human samples;

7. evaluation of findings and comparison of trend data by subpopulation, region, age, gender, etc.;

8. linkages between arctic health research and other programs (e.g. Great Lakes Health Effects Program);

9. presentation and mapping of data.

DESCRIPTION:

This project entails consultation, education, and health and illness baselines, including infant development evaluation, in addition to the laboratory studies. Resources for these components are to come from GNWT, Indian Affairs and Northern Development Canada (DIAND) and HWC, with non-monetary inputs from a variety of partners (listed). The laboratory analysis, however, will rely almost exclusively upon DIAND funds, though HWC will contribute services facilitation and analytical expertise, as may other linked partners. Ultimate relative risk interpretation and management direction will result from all-partner interaction.

ACTIVITIES/RESULTS IN 1991/92:

A consultation meeting was held with the staff of the Baffin Regional Health Board in Iqaluit on December 17, 1991. This meeting provided the opportunity for representatives from two NWT regions to exchange information and ideas about contaminants, and for further exchange of information with workers from the Northern Quebec Contaminants program. As well as being a valuable forum for information exchange, it was an opportunity to network with others concerned about issues surrounding contaminants and human health. A summary was distributed to all participants.

An Environmental Contaminants Workshop was held March 11 and 12, 1992 in Hay River, NWT to exchange technical information on contaminants and health, and to review ongoing contaminants-related initiatives with those involved in regional health programs. The workshop was also an opportunity to bring together Territorial representatives with individuals and agencies planning activities in the NWT. In addition to formal presentations on contaminants-related activities and technical information on contaminants and health, the agenda was designed to provide participants the opportunity to work in small groups. This allowed a more informal sharing of information, networking, and discussion about specific regional contaminants issues. The groups were also assigned the task of developing an effective process for local and regional consultation. Based on these discussions, participants thought it would be desirable to gather background information during the planning of community consultations.

Participants included representatives from Regional Health Services, the GNWT (Departments of Health, Renewable Resources, and Municipal and Community Affairs), Dene Nation, Metis Nation, Inuit Tapirisat of Canada (ITC), Arctic College, McGill and Laval Universities, DIAND and HWC.

These gatherings provided an integrated approach with an emphasis on communication. Participants felt the exchange would be very useful in their future activities.

Expected project completion date: March 31, 1997.

Partners: Aboriginal Organizations (Dene Nation, Metis Nation - NWT, Inuvialuit Regional Corporation and Inuit Tapirisat of Canada), DIAND, HWC, Northern Quebec Contaminants Program and the NWT.

RESOURCES:

	1991/92
AES Contaminants Program ($K)	30

CONTAMINANT MONITORING AND HUMAN HEALTH RISK ANALYSIS IN NATIVE NORTHERNERS

PROGRAM LEADERS: J.B. Walker, NWT Department of Health;
B. Elkin, NWT Department of Renewable Resources

OBJECTIVES:

1. Development of food consumption patterns study protocol.

2. Identification of shortcomings in data base on contaminant (includes chemical contaminants and radionuclides) and nutrient levels in country foods and conduct follow-up sampling.

3. Determination of human health implications (risks/benefits) including identification of populations at risk.

4. Development of advice to Northerners as required.

5. Development of remedial action plans including control options as applicable.

6. Analyze samples currently collected for routine measurements of gross radioactivity in air and precipitation for natural radionuclides for a period of five years to determine spatial and seasonal trends.

7. Provide laboratory support for analysis of contaminants (especially dioxins and PCBs) in food samples per year once GC-MS is in place.

8. Participate in sample/check quality assurance programs to ensure data integrity.

DESCRIPTION:

This project will examine both the diet and the harvest in representative areas of the NWT. It is an important link between human contaminant surveillance and wildlife contaminant studies in the North. Since the harvest studies referred to in the Northern Contaminants Research Plan were not conducted as anticipated in some areas, aspects of this part of the project may be incorporated into another Arctic Environmental Strategy project, where community-based "hands on" research training in dietary survey and harvest study procedures will be coordinated through representative organizations.

ACTIVITIES/RESULTS IN 1991/92:

(a) Health and Contaminants - An Annotated Bibliography (Draft Document)

Research and review articles related to Northern Health and Contaminants were compiled into an annotated bibliography. The information that has been entered into this document relates primarily to the circumpolar region with the primary emphasis placed on that relating to the Northwest Territories. This information was grouped into the following categories: (A) Acculturation, (B) Anthropology, (C) Northern Indigenous Food Habits, (D) Environmental Contaminants, (E) Health Status and Medical Assessment, (F) Nutrition Status, (G) Pregnancy, Childbirth Practices, Lactation and Infancy, and (H) Health Communication/Education. This document also contains an Index of Researchers and a Location Index (a listing of where the hard copies can be obtained within the NWT Department of Health). The bibliography is in draft form as it has not been completed. An example of the work still in progress is the addition of key words that will allow the user to pull all of the entries on a specific subject where the research has been completed in a specific Health Region area.

(b) Dietary Intake Methodologies - An Annotated Bibliography

A library search was completed to gather information on dietary intake methodologies. The articles that were obtained were grouped under the following headings: (1) Diet History, (2) Food Frequency, (3) 24-Hour Recall, (4) Food Intake Records, and (5) Other (miscellaneous). An index of Researchers is included. Hard copies are available from the Nutrition Section or the Contaminants Unit of NWT Department of Health.

These bibliographies will be directly used in 1992/93 in the development of the Training Module, which incorporates harvest and diet interview techniques and methods. They will also be imported to a sophisticated bibliographic data base which will be available to researchers and regional health staff. The latter, particularly, will input as well as access information.

Expected project completion date: March 31, 1997.

Partners: Aboriginal Organizations (Dene Nation, Metis Nation - NWT, Inuvialuit Regional Corporation and Inuit Tapirisat of Canada), Indian Affairs and Northern Development Canada, Health and Welfare Canada, Fisheries and Oceans Canada, and Canadian Wildlife Service.

RESOURCES:

	1991/92
AES Contaminants Program ($K)	28
GNWT ($K)	31

CENTRE FOR NUTRITION AND THE ENVIRONMENT OF INDIGENOUS PEOPLES (CINE)

PROGRAM LEADERS: H.V. Kuhnlein, T.A. Johns and the Centre Board, McGill University

PROGRESS:

This Centre was proposed following several years of discussions and support from the leaders of Canada's aboriginal organizations on the need for research expertise in traditional food systems and education in related research experiences. The proposal stressed the need for a research and training centre which is independent of Government, and which McGill and the project leaders are uniquely able to provide.

OBJECTIVES:

The centre will contribute to the goals and objectives of the AES by work on nutritional benefits and contaminant risks within the food systems of Indigenous Peoples in the Canadian North and the circumpolar world. Within the university context, the Centre's mission includes research and education with the integral involvement of Indigenous Peoples.

The important foci of the Centre's work are: 1) nutrition and the environment; 2) northern Canadian and circumpolar Indigenous Peoples; and 3) research with/for/by Indigenous Peoples with targets to publish in peer-reviewed literature and provide research training for Native People.

It is also an objective of the Centre to grow and expand interests and budgets to problems of nutrition and the environment of Indigenous groups outside of the Arctic.

ACTIVITIES:

To this point we have been building support networks with the Aboriginal Organizations and with Arctic College and Yukon College. We have tentative ideas on the kinds of research and education activities the Centre can assist Aboriginal People with, and we have held several conference calls and an Advisory Board Meeting. At the first Board Meeting, Bill Erasmus, Dene National Chief, was unanimously selected as Chair of the first Board, with the possibility of a co-Chair. Membership on the Board includes Dene Nation, Inuit Tapirisat of Canada, Inuit Circumpolar Conference, Metis Association of the NWT, Council for Yukon Indians, Assembly of First Nations, a representative of the AES, and the Centre Management staff.

Centre staff and the Board are now preparing a formal mission statement and terms of reference for the Board and the Centre.

Centre start-up activities will include renovations to a building on the Macdonald Campus, recruitment of two professorial staff and support staff, and meeting their laboratory and equipment needs. We will also establish the Centre with official McGill Centre Status within the Faculty of Graduate Studies and Research, which will include other interested faculty and their students. As well, the Centre will begin communications in earnest with aboriginal communities, and solicit formal project requests from Aboriginal Organizations.

In addition to the above, first year projects will concentrate on refining the dietary methodology necessary to get sufficient information for nutrition and contaminant evaluation with a minimum of community intrusion. As well, we plan to establish the first training/education courses requested by the Aboriginal Organizations with Arctic College and Yukon College.

LAKE LABERGE, YUKON - PRELIMINARY COMMUNITY BASED STUDY

PROGRAM LEADER: B. Wheatley, Medical Services Branch
Health and Welfare Canada

PRINCIPAL INVESTIGATORS: Ta'an Kwach'an

OBJECTIVES:

Identify community concerns, develop an appropriate action plan and develop strategies needed to respond to the complex environmental issues which impact on Ta'an Kwach'an, its community health and wellbeing, including the contamination of traditional foods.

ACTIVITIES:

A contribution agreement was negotiated for Ta'an Kwach'an to hold community meetings to identify community concerns relating to the health advisory given out for Lake Laberge, because of the levels of toxaphene found in burbot liver and lake trout. A preliminary document has been prepared by Ta'an Kwach'an under the agreement.

UTILIZATION OF RESULTS:

The base provided by the activities will be used for the planning with Ta'an Kwach'an of any future study on the impact of the contaminants in Lake Laberge on the Ta'an Kwach'an community.

RESOURCES EXPENDED:

$41,252.00 (50% of the original contribution agreement sum). Resources for 1992/93 and onward will depend on further discussions with Ta'an Kwach'an, and discussions with and linkages between Medical Services Branch, Health and Welfare Canada (Action Plan on Health and the Environment funding) and DIAND (Arctic Environmental Strategy funding).

DRAFT PROTOCOL FOR CONTAMINANTS RESEARCH OF COMMUNITY INTEREST

Prepared for the Inuit Circumpolar Conference by N. Doubleday

INTRODUCTION:

Northern aboriginal communities have often expressed concern with respect to the relationship between their communities and scientific researchers from elsewhere during the past twenty years. Efforts have been made to address these concerns by providing various statements to guide researchers in conducting research in the north (see, for example, the Inuit Circumpolar Conference "Comprehensive Arctic Policy Principles", "MAB Guidelines for Ethical Conduct of Research in the North", "Guidelines for Federal Scientific Activities in Canada's North", and "Arctic Human Sciences: Trends and Recommendations" by the International Arctic Science Ad Hoc Committee on Human Sciences in the Arctic).

In the Northwest Territories, a Science Institute has been created, with responsibility for informing communities of research interests and activities as part of a licensing procedure. All of these initiatives have made a contribution to the development of stronger ties between scientists and communities, but there have also been concerns about their effectiveness on one hand, and undue interference with scientific pursuits on the other.

In response, aboriginal organizations, governments and researchers have tried to develop mechanisms and strategies for dealing with sharing of information, participation and control over research. Some very successful partnerships have developed as a result of these initiatives, and the benefits of such arrangements have provided incentives for continuing cooperation.

A flexible approach is necessary as the nature of possible community interest and involvement will vary to some extent according to the subject matter and community expertise. For example, where the research in question is related to human health, wildlife, harvesting of renewable resources and utilization of country foods, Inuit and other aboriginal communities will undoubtedly be interested, resulting in greater needs for information sharing and direct community involvement. In order to encourage flexibility and cooperation, the Inuit Circumpolar Conference has begun to explore existing mechanisms to promote cooperation in research and to develop new approaches for consideration by Inuit communities and by researchers.

The present initiative results from the realization that based on a wide range of experiences, unhappy relationships between communities and researchers often have their origins in expectations, understandings and assumptions which are subsequently discovered to be one-sided; and in communication failures between the two parties. If the expectations and understandings of both the researchers and the communities were set out clearly at the

beginning of the research venture; fewer subsequent misunderstandings would arise.

The process of working out a mutual statement of understanding between communities and researchers will establish solid foundations for future communications. While this approach does require additional effort at the outset of the research project, it has the potential to offer great savings in time and effort in subsequent stages, as well as paying dividends with respect to communication of research results.

ISSUES FOR POSSIBLE EXPLORATION BY COMMUNITIES AND RESEARCHERS:

Issues of mutual concern and interest may include:

1) scope and purpose of research
2) funding of research and related support
3) research methods
4) community training and participation
5) ownership of data
6) confidentiality
7) access to analysis of data
8) distribution of results and final reports
9) media relations

CRITERIA FOR DEVELOPMENT OF A PROTOCOL:

Criteria for development and use of a protocol should be tailored to the community or communities and the research project or program under consideration, but in general include the following:

1) the protocol should be accessible and easy to use without any special training
2) it should be based on mutual respect and consideration of the legitimate needs of communities and researchers
3) it should include some means of evaluating the extent to which the provisions of the protocol have been honoured
4) it should include a reporting or feedback function by which the parties can communicate to the appropriate bodies their satisfaction with the arrangements made and the implementation of these arrangements.

In order for the feedback process to be effective in improving the arrangements made in this way, there must be some mechanism for responding appropriately to compliance or non-compliance. This mechanism should be designed to ensure improved performance where desirable rather than administering punitive measures.

The following draft model agreement represents one of the many possible approaches and is intended to promote discussion of the issues raised here.

DRAFT MODEL RESEARCH AGREEMENT

BETWEEN

NAME OF PRINCIPAL RESEARCHER_____
INSTITUTION_____
ADDRESS_____
_____
_____
_____

TELEPHONE_____

AND

COMMUNITY/ORGANIZATION_____
CONTACT PERSON_____
ADDRESS_____
_____
_____
_____

TELEPHONE_____

REGARDING PROJECT (TITLE AND DESCRIPTION)

_____
_____
_____
_____

The parties agree as follows regarding this research project/program: (DESCRIBE UNDER EACH HEADING)

1) SCOPE AND PURPOSE OF THE PROJECT/PROGRAM

2) METHODS TO BE USED

3) COMMUNITY TRAINING AND PARTICIPATION

4) OWNERSHIP OF DATA

5) ACCESS TO RESEARCH RESULTS

6) CONFIDENTIALITY

7) DISTRIBUTION OF RESEARCH RESULTS AND FINAL REPORTS WILL BE AS FOLLOWS

8) MEDIA RELATIONS

In the case of an expression of interest by the media in the research project or program, the parties agree that:

_____
_____
_____
_____
_____

9) DISCLOSURE OF FUNDING SOURCES AND OTHER FORMS OF SUPPORT FOR THIS PROJECT/PROGRAM

PRIMARY SOURCES
A) NAME OF FUNDING AGENCY_____

CONTACT PERSON IN AGENCY_____

ADDRESS _____
_____
_____
_____

TELEPHONE _____

SECONDARY SOURCES
b) NAME OF FUNDING AGENCY_____

CONTACT PERSON IN AGENCY_____

ADDRESS _____
_____
_____
_____

TELEPHONE _____

c) ADDITIONAL FUNDING AGENCIES (list)

10) STATEMENT OF COMMUNITY BENEFITS

TANGIBLE AND INTANGIBLE BENEFITS OF THE PROJECT/PROGRAM TO THE COMMUNITY INCLUDE

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11) COMMUNITY COMMITMENTS TO THE RESEARCHER

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12) RESEARCHER'S COMMITMENTS TO THE COMMUNITY

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SIGNED BY:

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